GATE 1998

MECHANICAL ENGINEERING

Duration: 3 Hours Maximum Marks:150

Read the following instructions carefully:

1. Write all the answers in the answer book.
2. This question paper consists of **TWO SECTIONS: A and B.**
3. **Section A** has **Eight** questions. Answer **ALL** questions in this section.
4. **Section B** has **Twenty** questions. Answer any **TEN** questions from this section. If more number of questions are attempted, strike off the answers not to be evaluated; else only the **FIRST TEN** unscored answers will be considered.
5. Answers to **Section B** should start on a fresh page and should not be mixed with answers to **Section A**.
6. Answers to questions and answers to parts of a question should appear together and should not be separated.
7. In all questions of 5 marks, write clearly the important steps in your answer. These steps carry partial credit.
8. There will be no negative marking.

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SECTION - A

1. This question consists of TWENTY-FIVE sub-questions (1.1 – 1.25) of ONE mark each. For each of these sub-questions, four possible alternatives (A, B, C and D) are given, out of which ONLY ONE is correct. Indicate the correct answer by darkening the appropriate bubble against the question number on the left hand side of the Objective Response Sheet (ORS). You may use the answer book provided for any rough work, if needed.

1.1 For $x = \frac{\pi}{6}$, the sum of the series $\sum_{1}^{\infty} (\cos x)^{2n} = \cos^2 x + \cos^4 x + \ldots$ is

(a) π (b) 3 (c) ∞ (d) 1

1.2 $(s+1)^{-2}$ is the Laplace transform of

(a) t^2 (b) t^3 (c) e^{-2t} (d) $te^{-t}\ 0 \Leftarrow 0$

1.3 If $\Phi(x) = \int_{0}^{x^2} \sqrt{t}\,dt$, then $\frac{d\Phi}{dx}$ is:

(a) $2x^2$ (b) $\sqrt{x}$ (c) 0 (d) 1

1.4 The magnitude of the gradient of the function $f = xyz^3$ at $(1, 0, 2)$ is:

(a) 0 (b) 3 (c) 8 (d) ∞

1.5 The probability that two friends share the same birth-month is:

(a) $\frac{1}{6}$ (b) $\frac{1}{12}$ (c) $\frac{1}{144}$ (d) $\frac{1}{24}$

1.6 A car moving with uniform acceleration covers 450 m in a 5 second interval, and covers 700 m in the next 5 second interval. The acceleration of the car is:

(a) 7 m/s^2 (b) 50 m/s^2 (c) 25 m/s^2 (d) 10 m/s^2

1.7 The buckling load for a column pinned at both ends is 10 kN. If the ends are fixed, the buckling load changes to

(a) 40 kN (b) 2.5 kN (c) 5 kN (d) 20 k N

1.8 The normal stresses at a point are $\sigma_x = 10$ MPa and, $\sigma_y = 2$ MPa; the shear stress at this point is 4 MPa. The maximum principal stress at this point is:

(a) 16 MPa (b) 14 MPa (c) 11 MPa (d) 10 MPa

1.9 The ratio of average shear stress to the maximum shear stress in a beam with a square cross-section is:

(a) 1 (b) $\frac{2}{3}$ (c) $\frac{3}{2}$ (d) 2

1.10 Heat transfer coefficient for free convection in gases, forced convection in gases and vapours, and for boiling water lie, respectively in the ranges of

(a) 5 – 15, 20 – 200 and 3000 – 50,000 W/m^2K.

(b) 20 – 50, 200 – 500 and 50,000 – 10^5 W/m^2K.

(c) 50 – 100, 500 – 1000 and 10^5 – 10^6 W/m^2K.

(d) 20 – 100, 200 – 1000, and a constant 10^6 W/m^2K.

1.11 If V_N and α are the nozzle exit velocity and nozzle angle in an impulse turbine, the optimum blade velocity is given by

(a) $V_N \cos 2\alpha$ (b) $V_N \sin 2\alpha$ (c) $\frac{V_N \cos\alpha}{2}$ (d) $\frac{V_N^2}{2}$

1.12 A Curtis stage, Rateau stage and a 50% reaction stage in a steam turbine are examples of

(a) different types of impulse stages

(b) different types of reaction stages

(c) a simple impulse stage, a velocity compounded impulse stage and reaction stage

(d) a velocity compounded impulse stage, a simple impulse stage and a reaction stage

1.13 The basic load rating of a ball bearing is

(a) the maximum static radial load that can be applied without causing any plastic deformation of bearing component.

(b) the radial load at which 90% of the group of apparently identical bearings run for one million revolutions before the first evidence of failure.

(c) the maximum radial load that can be applied during operation without any plastic deformation of bearing components.

(d) a combination of radial and axial loads that can be applied without any plastic deformation.

1.14 Decreasing grain size in a polycrystalline material

(a) increases yield strength and corrosion resistance

(b) decreases yield strength and corrosion resistance

(c) decreases yield strength but increases corrosion resistance

(d) increases yield strength but decreases corrosion resistance.

1.15 Auto collimator is used to check
(a) roughness (b) flatness
(c) angle (d) automobile balance

1.16 Failure of a bead weld between a heavy steel section and a thin section is mainly due to the formation of
(a) spheroidite (b) bainite
(c) carbon free zone due to burning of carbon at high temperature
(d) martensite.

1.17 Ideal surface roughness, as measured by the maximum height of unevenness, is best achieved when the material is removed by
(a) an end mill (b) a grinding wheel
(c) a tool with zero nose radius (d) a ball mill

1.18 In the specification of dimensions and fits,
(a) allowance is equal to bilateral tolerance
(b) allowance is equal to unilateral tolerance
(c) allowance is independent of tolerance
(d) allowance is equal to the difference between maximum and minimum dimension specified by the tolerance.

1.19. In machining using abrasive material, increasing abrasive grain size
(a) increases the material removal rate
(b) decreases the material removal rate
(c) first decreases and then increases the material removal rate
(d) first increases and then decreases the material removal rate

1.20. With increasing temperature of intake air, IC engine efficiency
(a) decreases (b) increases
(c) remains same (d) depends on other factors

1.21. Chills are used in moulds to
(a) achieve directional solidification
(b) reduce the possibility of blowholes
(c) reduce freezing time
(d) smoothen metal flow for reducing splatter.

1.22. One of the following statements about PRS (Periodic Reordering System) is not true. Identify,

(a) PRS requires continuous monitoring of inventory levels

(b) PRS is useful in control of perishable items

(c) PRS provides basis for adjustments to account for variations in demand

(d) In PRS, inventory holding costs are higher than in Fixed Recorder Quantity System

1.23. In inventory planning, extra inventory is unnecessarily carried to the end of the planning period when using one of the following lot size decision policies:

(a) Lot – for – lot production

(b) Economic Order Quantity (EOQ) lot size

(c) Period Order Quantity (POQ) lot size

(d) Part Period total cost balancing

1.24. In a weaving operation, the parameter to be controlled is the number of defects per 10 square yards of material. Control chart appropriate for this task is

(a) P - chart (b) C - chart (c) R - chart (d) $\bar{X}$ -Chart

1.25 Which one of the following forecasting techniques is not suited for making forecasts for planning production schedules in the short range?

(a) Moving average (b) Exponential moving average

(c) Regression analysis (d) Delphi

2. This question consists of TWENTY-FIVE sub-questions (2.1 – 2.25) of TWO marks each. For each of these sub-questions, four possible alternatives (A, B, C and D) are given, out of which ONLY ONE is correct.

2.1 The general solution of the differential equation $x^2 \frac{d^2y}{dx^2} - x\frac{dy}{dx} + y = 0$ is:

(a) $Ax + Bx^2$ (A,B are constants)

(b) $Ax + B\log x$ (A,B are constants)

(c) $Ax + Bx^2 \log x$ (A,B are constants)

(d) $Ax + Bx\log x$ (A,B are constants)

2.2. The best fit line using least squares for the data (0,0), (10, 24), (20, 36) and (30,60) is:

(a) 2x – y = 0 (b) 2x – y + 4 = 0

(c) 2x – y – 4 = 0 (d) None of these

2.3. The maximum principal strain in a thin cylindrical tank, having a radius of 25 cm and wall thickness of 5 mm when subjected to an internal pressure of 1 MPa, is (taking Young's modulus as 200 GPa and Poisson's ratio as 0.2)

(a) 2.25×10^{-4} (b) 2.25 (c) 2.25×10^{-6} (d) 22.5

2.4. A square bar of side 4 cm and length 100 cm is subjected to an axial load P. the same bar is then used as a cantilever beam and subjected to an end load P. the ratio of the strain energies, stored in the bar is the second case to that stored in the first case, is:

(a) 16 (b) 400 (c) 1000 (d) 2500

2.5. An IC engine has a bore and stroke of 2 units each. The area to calculate heat loss can be taken as

(a) 4π (b) 5π (c) 6π (d) 8π

2.6. An air breathing aircraft is flying at an altitude where the air density is half the value at ground level. With reference to the ground level, the air-fuel ratio at this altitude will be

(a) $\sqrt[3]{2}$ (b) $\sqrt{2}$ (c) 2 (d) 4

2.7. For the data listed below for two journal bearings A and B, predict the flow conditions in the bearings

Bearing	Diameter (m)	Radial clearance (m)	Surface speed of shaft (m/s)	Viscosity of lubricant (Pa – s)	Density of lubricant (kg/m^3)
A	0.01	10^{-5}	210	0.001	1000
B	0.05	10^{-4}	10	0.01	850

(a) laminar in both A and B (b) turbulent in both A and B
(c) Laminar in A and turbulent in B (d) turbulent in A and laminar B

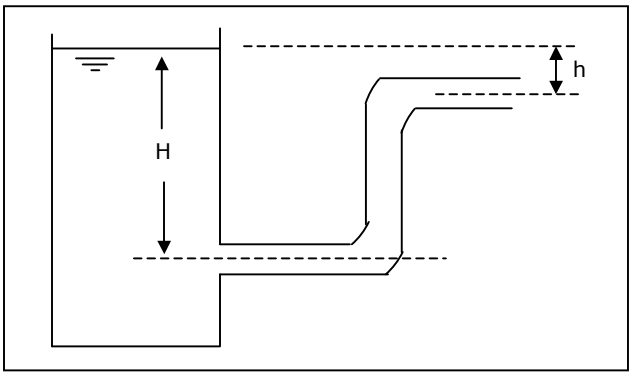
2.8. The isentropic heat drop in the nozzle of an impulse steam turbine with a nozzle efficiency 0.9, blade velocity ratio 0.5, and mean blade velocity 150 m/s in kJ/kg is

(a) 50 (b) 40 (c) 60 (d) 75

2.9. Air $\left(C_P = 1kJ/kg, \gamma = 1.4\right)$ enters a compressor at a temperature of 27°C. the compressor pressure ratio is 4. Assuming an efficiency of 80%, the compressor work required in kJ/kg is

(a) 160 (b) 172 (c) 182 (d) 225

2.10. The dicharge velocity at the pipe exit in figure 2.10 is



(a) $\sqrt{2gH}$

(b) $\sqrt{2gh}$

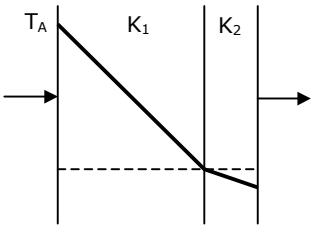
(c) $\sqrt{g(H+h)}$

(d) 0

2.11. A steel ball of mass 1 kg and specific heat 0.4 kJ/kg is at a temperature of 60°C. It is dropped into 1 kg water at 20°C. The final steady state temperature of water is:

(a) 23.5°C (b) 30°C (c) 35°C (d) 40°C

2.12. The temperature variation under steady heat conduction across a composite slab of two materials with thermal conductivities K_1 and K_2 is shown in Figure 2.12. Then, which one of the following statements holds?



(a) $K_1 > K_2$ (b) $K_1 = K_2$

(c) $K_1 = 0$ (d) $K_1 < K_2$

2.13. The earth can be assumed as a uniform sphere. Suppose the earth shrinks by 1% in diameter, the new day period

(a) will not change from 24 hours (b) will reduce by about 2%

(c) will reduce by about 1% (d) will increase by about 1%

2.14. Pertaining to a steam boiler, pick the correct statement among the following:

(a) Primary boiler heat surfaces include evaporator section, economizer and air preheater

(b) Primary boiler heat transfer surfaces include evaporator section, super heater section and economizer.

(c) Secondary boiler heat transfer surfaces include super heater, economizer and air preheater.

(d) Primary boiler heat transfer surfaces include evaporator section, super heater section and reheat section.

2.15. Consider the triangle formed by the connecting rod and the crank of an IC engine as the two sides of the triangle. If the maximum area of this triangle occurs when the crank angle is75°, the ratio of connecting rod length to crank radius is:

(a) 5 (b) 4 (c) 3.73 (d) 3

2.16. The difference between tensions on the tight and slack sides of a belt drive is 3000 N. If the belt speed is 15 m/s, the transmitted power in kW is

(a) 45 (b) 22.5 (c) 90 (d) 100

2.17. The profile of a cam in a particular zone is given by $x = \sqrt{3}\cos\theta$ and $y = \sin\theta$. The normal to the cam profile at $\theta = \frac{\pi}{4}$ is at an angle (with respect to x axis):

(a) $\frac{\pi}{4}$ (b) $\frac{\pi}{2}$ (c) $\frac{\pi}{3}$ (d) 0

2.18. In an orthogonal machining operation, the chip thickness and the uncut thickness are equal to 0.45 mm. If the tool rake angle is 0°, the shear plane angle is

(a) 45° (b) 30° (c) 18° (d) 60°

2.19. A strip with a cross-section 150 mm $\times$ 4.5 mm is being rolled with 20% reduction of area using 450 mm diameter rolls. The angle subtended by the deformation zone at the roll centre is (in radius):

(a) 0.01 (b) 0.02 (c) 0.03 (d) 0.06

2.20. A flywheel of moment of inertia 9.8 kg m^2 fluctuates by 30 rpm for a fluctuation in energy of 1936 Joules. The mean speed of the flywheel is (rpm)

(a) 600 (b) 900 (c) 968 (d) 2940

3. Match 4 correct pairs between List I and List II for questions 3.1 to 3.5 below. No credit will be given for partial matching. Write your answers using only the letters A to D and numbers 1 to 6.

3.1

List I	List II
(A) Heat to work	(1) Nozzle
(B) Heat to lift weight	(2) Endothermic chemical reaction
(C) Heat to strain energy	(3) Heat engine
(D) Heat to electromagnetic energy	(4) Hot air balloon/evaporation
	(5) Thermal radiation
	(6) Bimetallic strips

3.2

List I	List II
(A) Sand casting	(1) Symmetrical and circular shapes only
(B) Plaster mould casting	(2) Parts have hardened skins and soft interior
(C) Shell mould casting	(3) Minimum post-casting processing
(D) Investment casting	(4) Parts have a tendency to warp
	(5) Parts have soft skin and hard interior
	(6) Suitable only for non-ferrous metals

3.3.

List I	List II
(A) High head, low flow rate	(1) Streamlined body
(B) Low head, high flow rate	(2) Boundary layer
(C) Heat transfer	(3) Orifice meter
(D) Low drag	(4) Centrifugal pump
	(5) Axial flow pump
	(6) Nusselt number

3.4.

List I	List II
(A) Aluminium brake shoe	(1) Deep drawing
(B) Platstic water bottle	(2) Blow moulding
(C) Stainless steel cups	(3) Sand casting
(D) Soft drink can (aluminium)	(4) Centrifugal casting
	(5) Impact extrusion
	(6) Upset forging

3.5.

List I	List II
(A) ECM	(1) Plastic shear
(B) EDM	(2) Erosion/Brittle fracture
(C) USM	(3) Corrosive reaction
(D) LBM	(4) Melting and vapourization
	(5) Ion displacement
	(6) Platic shear and ion displacement

4. The radial displacement in a rotating disc is governed by the differential equation

$$\frac{d^2u}{dx^2} + \frac{1}{x}\frac{du}{dx} - \frac{u}{x^2} = 8x$$

where u is the displacement and x is the radius.

If u = 0 at x = 0, and u = 2 at x = 1, calculate the displacement at $x = \frac{1}{2}$

5. A component used in the Mars pathfinder can be idealized as a circular bar clamped at its ends. The bar should withstand a torque of 1000 Nm. The components is assembled on earth when the temperature is 30°C. Temperature on Mars at the site of landing is –70°C. the material of the bar has an allowable shear stress of 200 MPa and its Young's modulus is 200 GPa. Design the diameter of the bar taking a factor of safety of 1.5 and assuming a coefficient of thermal expansion for the material of the bar as 12×10^{-4} /°C.

6. A gas filled tube has 2 mm inside diameter and 25 cm length. The gas is heated by an electrical wire of diameter 50 microns (0.05 mm) located along the axis of the tube. Current and voltage drop across the heating element are 0.5 amps and 4 volts, respectively. If the measured wire and inside tube wall temperatures are 175°C and 150°C respectively, find the thermal conductivity of the gas filling the tube.

7. Two castings of the same metal have the same surface area. One casting is in the form of a sphere and the other is a cube. What is the ratio of the solidification time for the sphere to that of the cube?

8. The chemical formula for alcohol is C_2H_6O. Calculate the stoichiometric air/fuel ratio by mass and the percentage composition of the products of combustion per kg of C_2H_6O.

SECTION – B

Answer any TEN questions. Each question carries 5 marks.

9. For the composite beam shown in Figure 9, flexural rigidities EI of AB and DC are equal to $10^5 N-cm^2$, and EI of BD is $2\times10^5 N-cm^2$. Using moment – area theorem, determine the location and magnitude of maximum deflection between B and C.

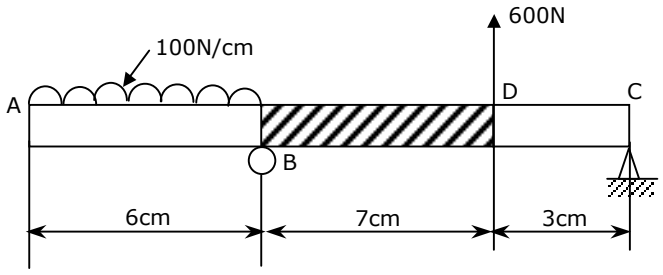
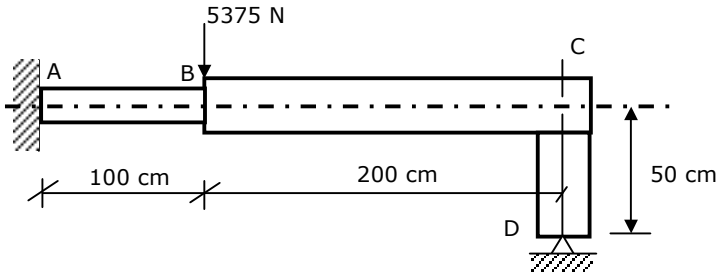


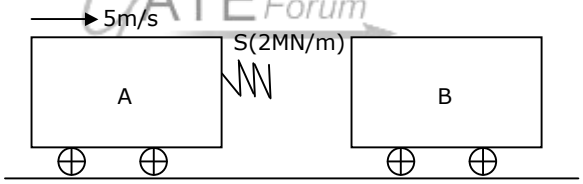
Fig.9

10. For the piping system shown in Figure 10, $(EI)_{AB} = 10^{11} N - cm^2$ and $(EI)_{BC} = 8 \times 10^{11} N - cm^2$. The axial rigidity of DC, $(EA)_{DC} = 10^7 N$. Determine the load on DC.

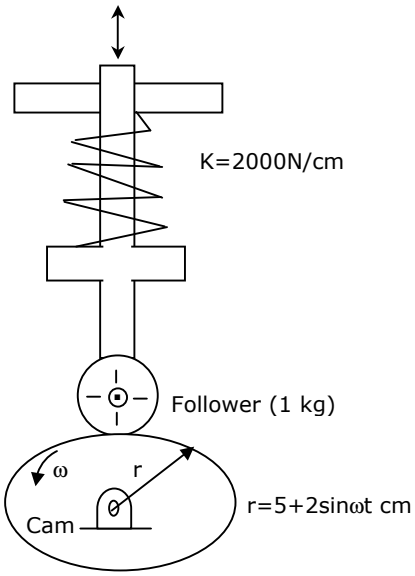


11. A cannon ball fired from the ground attained a maximum height of 1 km. At this maximum height, the radius of curvature of its path was also equal to 1 km. With this data, determine the initial velocity and angle of projection from the ground. Neglect air resistance.

12. A railway wagon (A) of mass 10,000 kg collides with another identical wagon (B) as shown in the figure 12. If A is moving at 5 m/s and B is at rest at the time of collision, calculate the maximum compression in the spring S with a spring constant of 2 MN/m.



13. A planar cam drives a translating follower as shown in the figure 13. the cam profile is given by r = 5 + 2 sin ωx cm where ω is the angular velocity of the cam. The cam is initially pressed by the follower by a compression spring of stiffness 2 kN/cm when r = 5 cm. Calculate the maximum operating speed of this system for the follower to maintain contact with the camp profile. The mass of the follower can be taken as 1 kg. The initial spring compression 1 5 mm.



14. A Rankine cycle operates between pressures of 80 bar and 0.1 bar. The maximum cycle temperature is 600°C. If the steam turbine and condensate pump efficiencies are 0.9 and 0.8, respectively, calculate the specific work and thermal efficiency. Relevant steam table extract is given below:

P bar	T°C	Specific volume m^3/kg		Specific enthalpy kJ/kg			Specific entropy kJ/kg K		
		V_f	V_g	h_f	h_{f_g}	h_g	S_f	S_{f_g}	S_g
0.1	45.84	0.0010103	14.68	191.9	2392.3	2584.2	0.6488	7.5006	8.1494
80	295.1	0.001385	0.0235	1317	1440.5	2757.5	3.2073	2.5351	5.7424

80 bar – 600°C	v	0.486
Superheat table	h	3642
	s	7.0206

15. A hot fluid at 200°C enters a heat exchanger at a mass flow rate of 10^4 kg/hr. Its specific heat is 2000J/kg K. It is to be cooled by another fluid entering at 25°C with a mass flow rate 2500 kg/hr and specific heat 400 J/kg K. the overall heat transfer coefficient based on outside area of $20m^2$ is 250 W/m^2K. Find the exit temperature of the hot fluid when the fluids are in parallel flow.

16. The minimum pressure and temperature in an Otto cycle are 100 kPa and 27°C. the amount of heat added to the air per cycle is 1500 kJ/kg. Determine the pressure and temperature at all points of the air standard Otto cycle. Also calculate the specific work and the thermal efficiency of the cycle for a compression ratio of 8:1. (Take C_v (air) as 0.72 kJ/kg K and $\left(\frac{C_p}{C_v}\right) = 1.4$)

17. Find the required air-fuel ratio in a gas turbine whose turbine and compressor efficiencies are 85% and 80% respectively. Maximum cycle temperature is 875°C. the working fluid can be taken as air $\left(C_p = 1.00 kJ/kg\ \text{K}, \gamma = 1.4\right)$, which enters the compressor at 1 atm and 27°C. The pressure ratio is 4. The fuel used has calorific value of 42000 kJ/kg. There is a loss of 10% of calorific value in the combustion chamber.

18. A turbocharged six-cylinder diesel engine has the following performance details:
    (i) Work done during compression and expansion = 820 kW.
    (ii) Work done during intake and exhaust = 50 kW.
    (iii) Rubbing friction in the engine = 150 kW.
    (iv) Net work done by turbine = 40 kW.

    If the brake means effective pressure is 0.6 MPa, determine the bore and the stroke of the engine taking the ratio of bore to stroke as 1 and engine speed as 100 rpm.

19. Select one of the following two bearings and justify why did you reject the other:

(a) Deep groove ball bearing

dynamic load rating = 47,000 N
radial factor (x) = 0.56
axial load factor (y) = 1.83

(b) Cylindrical roller bearing

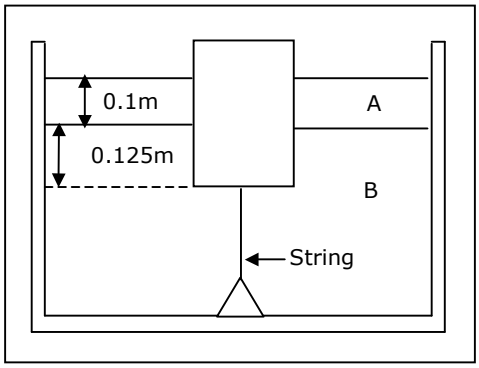
dynamic load rating = 28,000 N
radial factor (x) = 1.0
axial load factor (y) = 0.0
Life expectancy = 10,000 bar
Rotation factor = 1
Reliability factor = 0.62

Local condition

Radial load = 3,000 N
Axial load = 1,600 N
RPM = 1,000

20. A flat road has a curve segment with a radius of 100 m. while negotiating this curve, a vehicle slipped on its tyres as well as tried to rollover at a particular speed. Calculate this speed assuming a friction coefficient of 0.5. Also calculate the height of CG of the vehicle above ground if the tread (distance between the tyres at the front or rear) is 1.2 m.

21. A cylinder of mass 10 kg and area of cross-section $0.1m^2$ is tied down with string in a vessel containing two liquids as shown in Figure 21. Calculate gauge pressure on the cylinder bottom and the tension in the string. Density of water = 1000 kg/m^3. Specific gravity of A = 0.8. Specific gravity of B(water) = 1.0

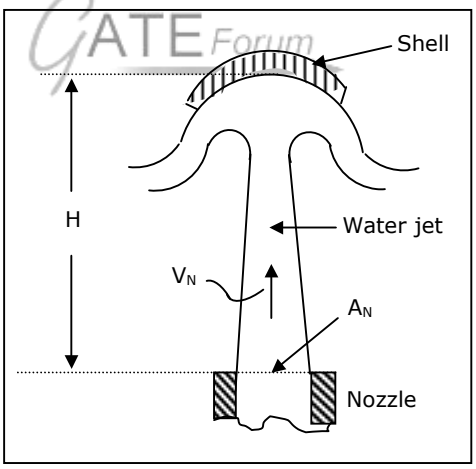


22. Hot water flows with a velocity of 0.1 m/s in a 100 m long, 0.1 m diameter pipe. Heat los from the pipe outer wall is uniform and equal to 420 W/m^2. If the inlet water temperature is 80°C, calculate the water temperature at the exit. Neglect effect of pipe wall thickness, $C_p\,(\text{water}) = 4.2$ kJ/kg °C and density of water = 1000 kg/m^3.

23. A farmer wishes to connect two pipes of different lengths and diameters to a common header supplied with 8×10^3 m^3/s of water from a pump. One pipe is 100 m long and 5 cm in diameter. The other pipe is 800 m long. Determine the diameter of the second pipe such that both pipes have the same flow rate. Assume the pipes to be laid on level ground and friction factor for both pipes as 0.02. Also determine the head loss in metres of water in the pipes.

Note: Pressure drop = $f \frac{1}{2} \rho v^2 \frac{L}{D}$, where f is friction factor.

24. A vertical jet of water is able to keep hemispherical shell as shown in Figure 24. The water jet is issuing from a nozzle of area A_N with a velocity V_N at the nozzle exit. Using Bernoulli's equation and momentum theorem develop expression for jet velocity at the shell and the height H at which the shell is balanced. Shell mass = m. water density is ρ, and assume ideal flow.



25. The voltage (V) – length (l) characteristic of a d.c. arc is given by V = 20 + 4l Volt (l in mm). During a welding operation the arc length is expected to vary between 4 and 6 mm with the welding current limited between 450 and 550 amps. If the power source has a linear characteristic, calculate the arc power at an a.c. length of 5-mm. What is the open circuit voltage?

26. In a plain slab up-milling operation with a straight cutter, the diameter is 50 mm and the depth of cut is 7.32 mm. Number of teeth on the cutter is 8. Plot the variation of torque with the arbor rotation.

27. A cylinder of 155 mm is to be reduced 150 mm diameter in one turning cut with a feed of 0.15 mm/ revolution and a cutting speed of 150 m/min on a NC lathe. What are the programmed spindle speeds programmed feed rate, and the material removal rate?

28. A job shop has 6 orders to be completed by a single turning centre. The processing times and due dates are as follows:

Order	1	2	3	4	5	6
Processing time	3	2	9	4	2	4
Due date	17	21	5	12	15	24

Assume that all orders are ready for processing.

Give a production schedule that minimizes the average flow time. Compare this schedule with one that minimizes tardiness (lateness).

SECTION - A

1. This question consists of TWENTY-FIVE sub-questions (1.1 – 1.25) of ONE mark each. For each of these sub-questions, four possible alternatives (A, B, C and D) are given, out of which ONLY ONE is correct. Indicate the correct answer by darkening the appropriate bubble against the question number on the left hand side of the Objective Response Sheet (ORS). You may use the answer book provided for any rough work, if needed.

1.1 Rank of the matrix given below is:

$$\begin{bmatrix} 3 & 2 & -9 \\ -6 & -4 & 18 \\ 12 & 8 & -36 \end{bmatrix}$$

(a) 1 (b) 2 (c) 3 (d) $\sqrt{2}$

1.2 For the function $\phi = ax^2y - y^3$ to represent the velocity potential of an ideal fluid, $\nabla^2\phi$ should be equal to zero. In that case, the value of 'a' has to be:

(a) -1 (b) 1 (c) -3 (d) 3

1.3 If the velocity vector in a two – dimensional flow field is given by $\vec{v} = 2xy\vec{i} + \left(2y^2 - x^2\right)\vec{j}$, the vorticity vector, curl $\vec{v}$ will be

(a) $2y^2\vec{j}$ (b) $6y\vec{k}$ (c) zero (d) $-4x\vec{k}$

1.4 Laplace transform of $(a+bt)^2$ where 'a', and 'b' are constants is given by:

(a) $(a+bs)^2$ (b) $\dfrac{1}{(a+bs)^2}$

(c) $\dfrac{a^2}{s} + \dfrac{2ab}{s^2} + \dfrac{2b^2}{s^3}$ (d) $\dfrac{a^2}{s} + \dfrac{2ab}{s^2} + \dfrac{b^2}{s^3}$

1.5 Following are the values of a fucntion y(x):y(-1)=5,y(0),Y(1)=8, $\dfrac{dy}{dx}$ at x = 0 as per Newton's central difference scheme is:

(a) 0 (b) 1.5 (c) 2.0 (d) 3.0

1.6 Analysis of variance is concerned with:

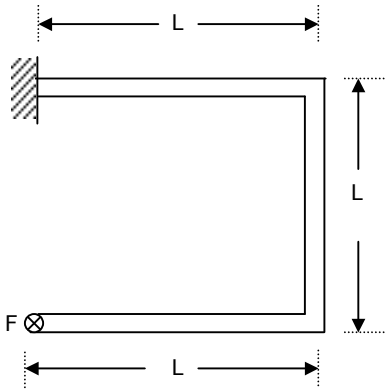
(a) determining change in a dependent variable per unit change in an independent variable

(b) determining whether a qualitative factor affects the mean of an output variable

(c) determining whether significant correlation exists between an output variable and an input variable

(d) determining whether variances in two or more populations are significantly different.

1.7 A concentrated force, F, is applied (perpendicular to the plane of the figure) on the tip of the bent bar shown in Fig.1.7. The equivalent load at a section close the fixed end is:



(a) Force F

(b) Force F and bending moment FL

(c) Force F and twisting moment FL

(d) Force F, bending moment F L, and twisting moment FL

1.8 Which theory of failure will you use for aluminium components under steady loading:

(a) Principal stress theory (b) Principal strain theory

(c) Strain energy theory (d) Maximum shear stress theory

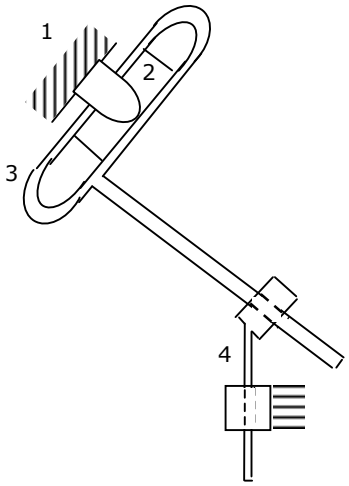
1.9 For the planar mechanism shown in Fig.1.9, select the most appropriate choice for the motion of link 2 when link 4 is moved upwards.

(a) Link 2 rotates clockwise

(b) Link 2 rotates counter - clockwise

(c) Link 2 does not move

(d) Link 2 motion cannot be determined



1.10 $\frac{\partial^2 u}{\partial t^2} = C^2 \frac{\partial^2 u}{\partial x^2}$ represents the equation for:

(a) Vibration of a stretched string

(b) Motion of a projective in a gravitational field

(c) Heat flow in thin rod

(d) Oscillation of a simple pendulum

1.11 Bolts in the flanged end of pressure vessel are usually pre-tensioned. Indicate which of the following statements in NOT TRUE.

(a) Pre-tensioning helps to seal the pressure vessel

(b) Pre-tensioning increases the fatigue life of the bolts

(c) Pre-tensioning reduces the maximum tensile stress in the bolts

(d) Pre-tensioning helps to reduce the effect of pressure pulsations in the pressure vessel

1.12 If 'p' is the gauge pressure within a spherical droplet, the gauge pressure within a bubble of the same fluid and of same size will be

(a) $\frac{p}{4}$ (b) $\frac{p}{2}$ (c) p (d) $2p$

1.13 If velocity of water inside a smooth tube is doubled, the turbulent flow heat transfer coefficient between the water and the tube will

(a) remain unchanged

(b) increase to double its value

(c) increase but will not reach double its value

(d) increase to more than double its value

1.14 A Stirling cycle and a Carnot cycle operate between 50°C and 350°C. Their efficiencies are η_s and η_c respectively. In this case, which of the following statements is true?

(a) $\eta_s > \eta_c$ (b) $\eta_s = \eta_c$ (c) $\eta_s < \eta_c$

(d) The sign of $(\eta_s - \eta_c)$ depends on the working fluids used

1.15 A Carnot cycle refrigerator operates between 250 K and 300 K. Its coefficient of performance is:

(a) 6.0 (b) 5.0 (c) 1.2 (d) 0.8

1.16 In a pulverized-fuel-fired large power boiler, the heat transfer from the burning fuel to the walls of the furnace is

(a) by conduction only
(b) by convection only
(c) by conduction and convection
(d) predominantly by radiation

1.17 A gas turbine power plant has a specific output of 350 kJ/kg and an efficiency of 34%. A regenerator is installed and the efficiency increases to 51%. The specific output will be closest to

(a) 350 kJ/kg (b) 468 kJ/kg (c) 525 kJ/kg (d) 700 kJ/kg

1.18 Kinematic viscosity of air at 20°C is given to be $1.6\times10^{-5} m^2/s$. Its kinematic viscosity at 70°C will be vary approximately

(a) $2.2\times10^{-5}\text{m}^2/\text{s}$
(b) $1.6\times10^{-5}\text{m}^2/\text{s}$
(c) $1.2\times10^{-5}\text{m}^2/\text{s}$
(d) $10^{-5}\times\text{m}^2/\text{s}$

1.19. Which of the following statements does NOT apply to the volumetric efficiency of a reciprocating air compressor

(a) It decreases with increase in inlet temperature
(b) It increases with decrease in pressure ratio
(c) It increases with decrease in clearance ratio
(d) It decreases with increase in clearance to stroke ratio

1.20. Ambient air dry-bulb temperature is 45°C and wet bulb temperature is 27°C. Select the lowest possible condensing temperature from the following for an evaporatively cooled condenser.

(a) 25°C (b) 30°C (c) 42°C (d) 48°C

1.21. Identify the stress –state in the FLANGE portion of a PARTIALLY DRAWN CYLINDRICAL CUP when deep – drawing without a blank holder

(a) Tensile in all three directions
(b) No stress in the flange at all, because there is no blank - holder
(c) Tensile stress in one direction and compressive in the other direction
(d) Compressive in two directions and tensile in the third direction

1.22. Which of the following materials requires the largest shrinkage allowance, while making a pattern for casting?

(a) Aluminium
(b) Brass
(c) Cast Iron
(d) Plain Carbon Steel

1.23. In Electro-Discharge Machining (EDM), the tool is made of:

(a) Copper (b) High Speed Steel

(c) Cast Iron (d) Plain Carbon Steel

1.24. Choose the correct statement:

(a) A fixture is used to guide the tool as well as to locate and clamp the work piece

(b) A jig is used to guide the tool as well as to locate and clamp the work piece

(c) Jigs are used on CNC machines to locate and clamp the work piece and also to guide the tool

(d) No arrangements to guide the tool is provided in a jig

1.25 The first algorithm for Linear Programming was given by:

(a) Bellman (b) Dantzing

(c) Kulm (d) von Neumann

2. This question consists of TWENTY-FIVE sub-questions (2.1 – 2.25) of TWO marks each. For each of these sub-questions, four possible alternatives (A, B, C and D) are given, out of which ONLY ONE is correct. Indicate the correct answer by darkening the appropriate bubble against the question number on the left hand side of the Objective Response Sheet (ORS). You may use the answer book provided for any rough work, if needed.

2.1 The eigen values of the matrix

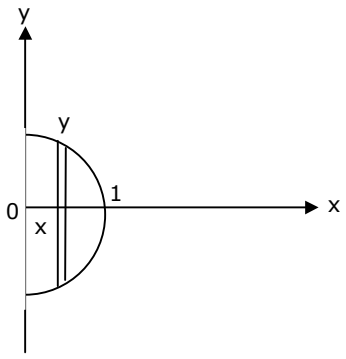
$$\begin{bmatrix} 5 & 3 \\ 3 & -3 \end{bmatrix}$$ are:

(a) 6 (b) 5 (c) -3 (d) -4

2.2. The static moment of the area of a half circle of unit radius about y-axis (see Fig.2.2) $\int_0^{x=1} 2xydx$ is equal to

(a) $\frac{2}{3}$ (b) $\frac{\pi}{8}$

(c) $\frac{\pi}{2}$ (d) $\frac{\pi}{4}$



2.3. In a flow field in x, y – plane, the variation of velocity with time t is given by $v = \left(x^2 + yt\right)\vec{i}$

$$\vec{v} = \left(x^2 + y^2\right)\vec{i}$$

The acceleration of the particle in this field, occupying point (1,1) at time t = 1 will be

(a) $\vec{i}$ (b) $2\vec{i}$ (c) $3\vec{i}$ (d) $5\vec{i}$

2.4. $\frac{d^2y}{dx^2} + \left(x^2 + 4x\right)\frac{dy}{dx} + y = x^8 - 8$.

The above equation is a

(a) partial differential equation

(b) nonlinear differential equation

(c) non-homogeneous differential equation

(d) ordinary differential equation

2.5. We wish to solve $x^2 - 2 = 0$ by Newton Raphson technique. Let the initial guess $bx_0 = 1.0$ subsequent estimate of x (i.e. x_1) will be:

(a) 1.414 (b) 1.5 (c) 2.0

(d) None of the above

2.6. Four arbitrary points $(x_1, y_1), (x_2, y_2), (x_3, y_3), (x_4, y_4)$ are given in the x,y – plane. Using the method of least squares, if, regressing y upon x gives the fitted line y = ax + b; and regressing y upon x gives the fitted line y = ax + b; and regressing x upon y gives the fitted line x = cy + d, then

(a) the two fitted lines must coincide

(b) the two fitted lines need not coincide

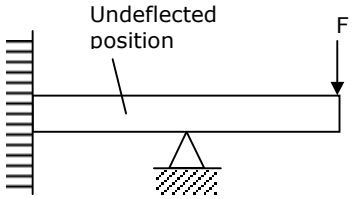
(c) it is possible that ac = 0

(d) a must be $\frac{1}{c}$

2.7. A thin walled cylindrical vessel of wall thickness *t* and diameter *d* is filled with gas to a gauge pressure of *p*. the maximum shear stress on the vessel wall will then be

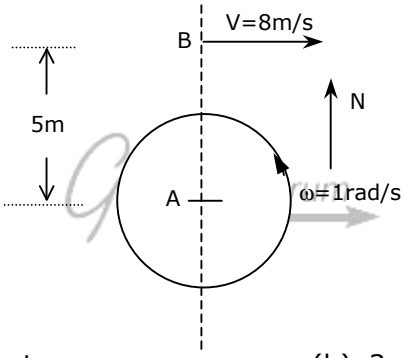
(a) $\frac{pd}{t}$ (b) $\frac{pd}{2t}$ (c) $\frac{pd}{4t}$ (d) $\frac{pd}{8t}$

2.8. A lean elastic beam of given flexural rigidity, EI, is loaded by a single force F as shown in Fig.2.8. How many boundary conditions are necessary to determine the deflected centerline of the beam?



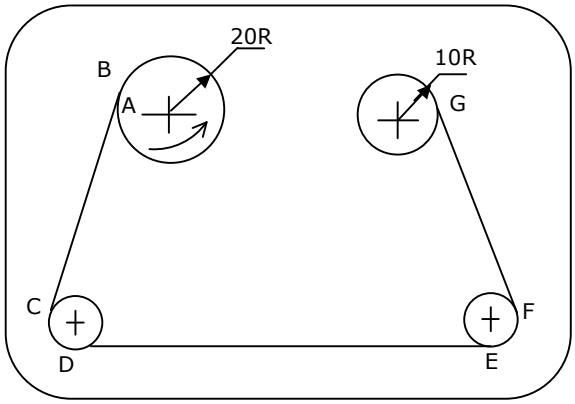
(a) 5 (b) 4 (c) 3 (d) 2

2.9. A shown in Fig.2.9, a person A is standing at he centre of a rotating platform facing person B who is riding a bicycle, heading East. The relevant speeds and distances are shown in Fig.2.9 a person a bicycle, heading East. At the instant under consideration, what is the apparent velocity of B as seen by A?



(a) 3 m/s heading East (b) 3 m/s heading West
(c) 8 m/s heading East (d) 13 m/s heading East

2.10. For the audio cassette mechanism shown in Fig.2.10, where is the instantaneous centre of rotation (point) of the two spools?



(a) Point P lies to the left of both the spools but a infinity along the line joining A and H

(b) Point P lies in between the two spools on the line joining A and H, such that $\overline{PH} = 2\overline{AP}$

(c) Point P lies to the right of both the spools on the line joining A and H, such that $\overline{AH} = \overline{HP}$

(d) Point P lies at the intersection of the line joining B and C and the line joining G and F

2.11. With regard to belt drives with given pulley diameters, centre distance and coefficient of friction between the pulley and the belt materials, which of the statements below are FALSE?

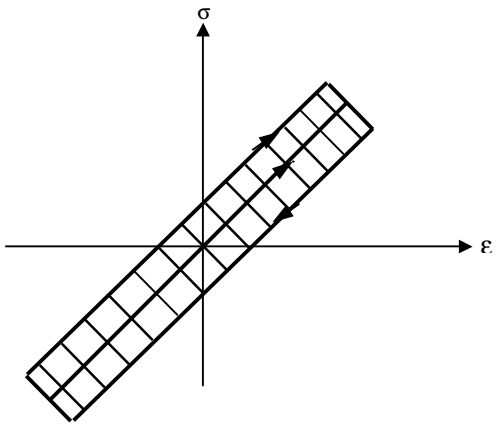
(a) A crossed flat belt configuration can transmit more power than an open flat belt configuration

(b) A 'V' belt has greater power transmission capacity than an open belt

(c) Power transmission is greater when belt tension is higher due to centrifugal effects than the same belt drive when centrifugal affects are absent

(d) Power transmission is the greatest just before the point of slipping is reached

2.12. Under repeated loading a material has the stress-strain curve shown in Fig.2.12. Which of the following statements is true?



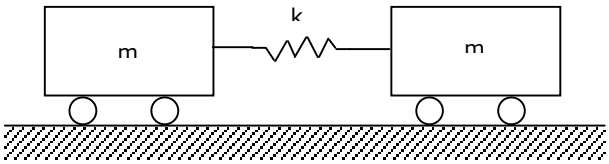
(a) The smaller the shaded area, the better the material damping

(b) The larger the shaded area, the better the material damping

(c) Material damping is an independent material property and does not depend on this curve

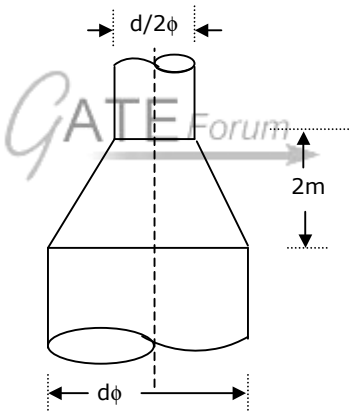
(d) None of the above

2.13. Consider the system of two wagons shown in Fig.2.13. The natural frequencies of this system are



(a) $0, \frac{\sqrt{2k}}{m}$ (b) $\frac{\sqrt{k}}{m}, \frac{\sqrt{2k}}{m}$ (c) $\frac{\sqrt{k}}{m}, \frac{\sqrt{k}}{2m}$ (d) $0, \frac{\sqrt{k}}{2m}$

2.14. Water flows through a vertical contraction from a pipe of diameter d to another of diameter $\frac{d}{2}$(see Fig.2.14). The flow velocity at the inlet to the contraction is 2m/s and pressure 200 kN/m^2. If the height of the contraction measures 2m, the pressure at the exit of the contraction will be very nearly



(a) 168 kN/m^2 (b) 192 kN/m^2
(c) 150 kN/m^2 (d) 174 kN/m^2

2.15. An aero plane is cruising at a speed of 800 kmph at an altitude, where the air temperature is 0°C. The flight Mach number at this speed is nearly

(a) 1.5 (b) 0.254 (c) 0.67 (d) 2.04

2.16. It is proposed to coat a 1 mm diameter wire with enamel paint (k = 0.1 W/mK) to increase heat transfer with air. If the air side heat transfer coefficient is 100 W/m^2 K, the optimum thickness of enamel paint should be

(a) 0.25 mm (b) 0.5 mm (c) 1 mm (d) 2 mm

2.17. An isolated thermodynamic system executes a process. Choose the correct statement (s) from the following:

(a) No heat is transferred

(b) No work is done

(c) No mass flows across the boundary of the system

(d) No chemical reaction takes place within the system

2.18. The silencer of an internal combustion engine

(a) reduces noise

(b) decreases brake specific fuel consumption (BSFC)

(c) increases BSFC

(d) has no effect on its efficiency

2.19. Select statements from List II matching the processes in List I. Enter your answer as D, C if the correct choice for (1) is (D) and that for (2) is (C)

List I	List II
(1) Cooling and dehumidification	(A) Dry bulb temperature increases, but, dew – point temperature decreases
(2) Chemical dehumidification	(B) Dew – point temperature increases and dry – bulb temperature remains unchanged
	(C) Dry – bulb and wet – bulb temperature decrease
	(D) dry – bulb temperature decreases, but, dew – point temperature increases

2.20. Select statements from List II matching the processes in List I. Enter your answer as A, B if the correct choice for (1) is (A) and that for (2) is (B)

List I	List II
(1) Intercooling	(A) No heat transfer during compression
(2) Isothermal compression	(B) Reduces low pressure compressor work
	(C) Heat rejection during compression
	(D) Reduces high pressure compressor work

2.21. For butt – welding 40 mm thick steel plates, when the expected quantity of such jobs is 5000 per month over a period of 10 years, choose the best suitable welding process out of the following available alternatives.

(a) Submerged arc welding

(b) Oxy – acetylene gas welding

(c) Electron beam welding

(d) MIG welding

2.22. What is approximate percentage change is the life, t, of a tool with zero rake angle used in orthogonal cutting when its clearance angle, α, is changed from 10° to 7°? (Hint: Flank wear rate is proportional to cot α)

(a) 30% increase (b) 30% decrease

(c) 70% increase (d) 70% decrease

2.23. Suppose X is a normal random variable with mean 0 and variance 4. Then the mean of the absolute value of X is

(a) $\frac{1}{\sqrt{2\pi}}$ (b) $\frac{2\sqrt{2}}{\sqrt{\pi}}$ (c) $\frac{2\sqrt{2}}{\pi}$ (d) $\frac{2}{\sqrt{\pi}}$

2.24. In computing Wilson's economic lot size for an item, by mistake the demand rate estimate used was 40% higher than the tree demand rate. Due to this error in the lot size computation, the total cost of setups plus inventory holding per unit time, would rise above the true optimum by approximately

(a) 1.4% (b) 6.3% (c) 18.3% (d) 8.7%

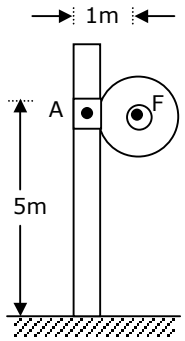
2.25. At a production machine, parts arrive according to a Poisson process at the rate of 0.35 parts per minute. Processing time for parts have exponential distribution with mean of 2 minutes. What is the probability that a random part arrival finds that there are already 8 parts in the system (in machine + in queue)?

(a) 0.0247 (b) 0.0576 (c) 0.0173 (d) 0.082

SECTION – B

This section consists of TWENTY questions of FIVE marks each. Attempt ANY FIFTEEN questions. Answers must be given in the answer book provided. Answer for each question must start on a fresh page and must appear at one place only. (Answers to all parts of a question must appear together).

3. Consider the sign board mounting shown in Fig.3. The wind load acting perpendicular to the plane of the figure is F = 100N. We wish to limit the deflection, due to bending, at point A of the hollow cylindrical pole of outer diameter 150 mm, to 5 mm. Find the wall thickness for the pole. Assume $E = 2.0 \times 10^{11} N/m^2$.



4. The peak bending stress at critical section of a component varies between 100 MN/m^2 and 300 MN/m^2. The ultimate tensile strength of the material is 700 MN/m^2, yield point in tension is 500 MN/m^2, and endurance limit for reversed bending is 350 MN/m^2. Find the factor of safety.

5. A proper base isolation is to be designed for mounting a sensitive instrument as shown in Fig.5. at the point of mounting, the base vibration due to other disturbances is indicated in the figure. If the permitted absolute displacement amplitude on the rigid mounting pad is 0.001 mm, find the stiffness of the spring. Assume that the total mass of the mounting pad and the instrument is 50 kg.

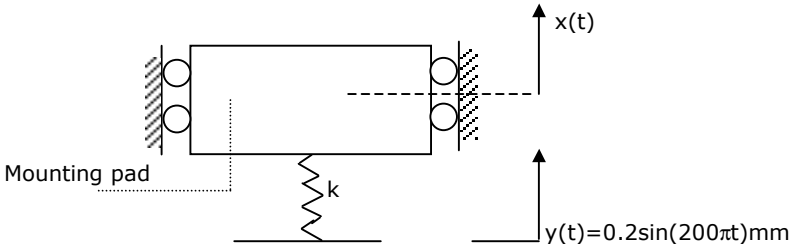
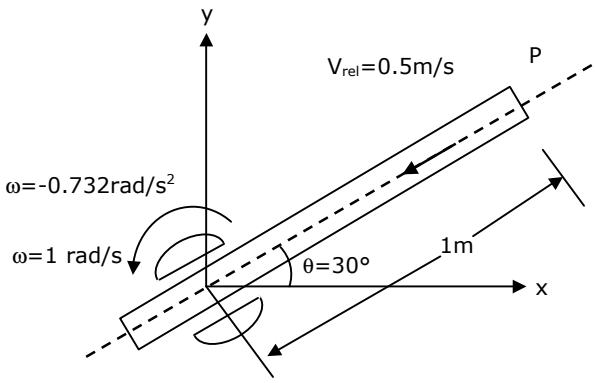
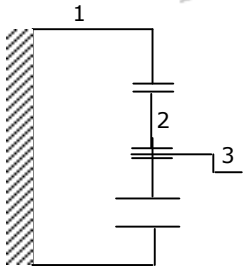


Fig.5

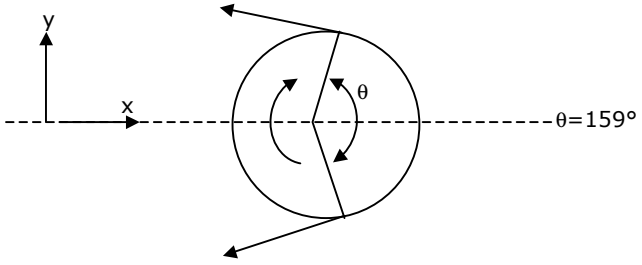
6. Figure 6 shows a 2-degree of freedom manipulator consisting of a rotary base and a sliding arm, which slides radially with respect to the base. The instantaneous position, angular velocity, angular acceleration and relative velocity of arm with respect to the base are shown in Fig.6. The radial relative acceleration of the arm with respect to the base is zero. Obtain the magnitude and direction of the absolute acceleration of the point P on the sliding arm.



7. A planetary gear train is shown in Fig.7. Internal gear (1) has 104 teeth and is held fixed and planet gear (2) has 96 teeth. How much does the planet gear rotate for sixty revolutions of the planet carrier (3) in clockwise direction?



8. A flat belt open drive transmits 1.5 kW of power. The coefficient of friction between the belt and the drive pulley is 0.25 and the lap angle is 159°. The drive pulley is rotating in the clockwise direction with the linear belt velocity of 3.75 m/s. Determine the x and y components of the reaction force on the drive pulley shaft.



9. A centrifugal pump running at 750 rpm discharges water at 0.1m^3/s against a head of 10 m at its best efficiency. A second pump of the same homologous series, when working at 500 rpm, is to deliver water at 0.05 m^3/s at its best efficiency. What will be the design head of the second pump and what is the scale ratio between the first and the second?

10. Two fluids, A and B exchange heat in a counter-current heat exchanger. Fluid A enters at 420°C has a mass flow rate of 1 kg/s. Fluid B enters a 20°C and also has a mass flow rate of 1 kg/s Effectiveness of heat exchanger is 75%. Determine the heat transfer rate and exit temperature of fluid B. (Specific heat Fluid A is 1 kJ/kgK and that of Fluid B is 4 kJ/kgK).

11. An R-717 (ammonia) system operates on the basic vapour compression refrigeration cycle. The evaporator and the condenser pressures are 0.119 MPa and 1.389 MPa respectively. The mass flow rate of refrigerant is 0.1 kg/s. If the volumetric efficiency of the compressor is 84%, determine the compressor displacement rate. If the COP of the cycle is 2, determine the power input to the compressor.

Saturation properties of R-717 (ammonia)

Temperature °C	Pressure MPa	Specific Volume of Vapour, m^3/kg	Enthalpy kJ/kg	
			Liquid	Vapour
-30	0.119	0.9638	63.9	1423.6
36	1.389	0.0930	371.4	1488.6

12. A large diesel engine runs on a stroke cycle at 2000 rpm. The engine has a displacement of 25 litre and a brake mean effective pressure of 0.6 MN/m^2. It consumes 0.018 kg/s of fuel (calorific value = 42000 kJ/kg). Determine the brake power and the brake thermal efficiency.

13. An isentropic air turbine is used to supply 01. kg/s of air at 0.1 MN/m^2 and at 285 K to a cabin. The pressure at inlet to the turbine is 0.4 MN/m^2. Determine the temperature at turbine inlet and the power developed by the turbine. Assume $C_P = 1.0kJ/kgK$.

14. An adiabatic steam turbine receives dry saturated steam at 1.0 MN/m^2 and discharges it at 0.1 MN/m^2. The steam flow rate is 3 kg/s and the moisture at exit in negligible. If the ambient temperature is 300 K, determine the rate of entropy production and the lost power.

Steam properties:

P MN/m^2	T_{sat} °C	h_f kJ/kg	h_g kJ/kg	s_f kJ/kgK	s_g kJ/kgK
1.0	179.9	762.8	2778.1	2.139	6.586
0.1	99.6	417.5	2675.5	1.303	7.359

15. In a butt – welding operation on plates, the heat input necessary is given by

$$Q = 8KT_c t\left[0.2 + \frac{vb}{4\alpha}\right]$$

where

K is thermal conductivity

T_c is temperature increase from room temperature up to melting point.

t is thickness of plate

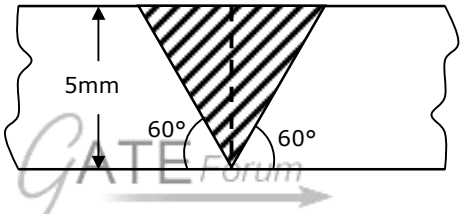
v is welding speed

b is width of the weld and

α is thermal diffusivity

Two alloy steel plates as shown in Fig.15 are to be welded using a power source rated at 5 kVA having a duty cycle of 75%. Using the given data, determine the MAXIMUM welding speed for the job given in fig.15.

Data: K = 45W/m°C, T_c = 145°C, and $\alpha = 1.2 \times 10^{-5}$ m^2/s

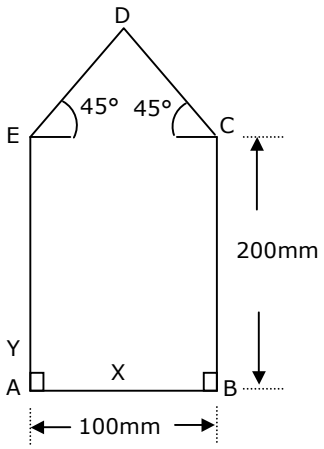


16. In a particular mould design, the down sprue has an area of cross section of 6.45cm^2 where the pouring basin leads into the sprue. The sprue is 20 cm long. The required metal flow rate at the top section of the sprue is 820 cm^3/s. determine the pouring height necessary above the sprue top. Also determine the area of cross-section of the sprue at its bottom to avoid aspiration of liquid metal.

17. The shape ABCDE shown in Fig.17 is to be produced by blanking operation from a largest sheet of 4 mm thickness. The material is alloy steel having ultimate shear strength, USS of 600 MPa.

(a) Calculate the force required in the blanking operation.

(b) Determine the coordinates of the "centre of pressure" during the operation with origin at A.



18. A_1 is the diameter of a random part of type A and A_1 has Uniform distribution over the tolerance range, (25.0, 25.3) mm. Similarly, B_1 is the diameter of a random part of type B and B_1 has Uniform distribution over the tolerance range, (25.4, 25.6) mm. Satisfactory assembly of type A part with a type B part requires that the clearance ($B_1 - A_1$) must be between 0.1 mm and 0.4 mm.
    (i) List the corner points of the region in the X – Y plane where (A_1, B_1) would lie in the event of satisfactory assembly between A_1 and B_1.
    (ii) Derive the probability that A_1 and B_1 do NOT give satisfactory assembly.

19. Demands for parts in weeks 1, 2, 3 are : 200, 300, 500 units respectively while available capacities for production in the three weeks are for: 350, 350, 350 units respectively. Inventory holding cost is Rs.h per week.
    (i) To minimize total Inventory holding cost while meeting demands on time, determine the production quantities in weeks 1, 2, 3.
    (ii) If the optimization problem above is formulated as a Linear Program, determine the Shadow Price of the capacity constraint in the THIRD week.

20. In an orthogonal cutting experiment with a tool of rake angle γ=7°, the chip thickness was found to be 2.5 mm when the uncut chip thickness was set to 1 mm.
    (a) Find the shear angle ϕ
    (b) Find the friction angle β assuming that Merchant's formula holds good.

21. The lives of two tools, A and B, governed by the equations $vt^{0.125} = 2.5$ and $vt^{0.250} = 7$ respectively in certain machining operation where y is the cutting speed in m/s and t is the tool life in seconds.
    (a) Find out the speed v* at which both the tools will have the same life. Also calculate the corresponding tool life t*.
    (b) If you have to machine at a cutting speed of 1 m/s, which one of these tools will you choose in order to have less frequent tool changes?

22. The bore diameter, D, of a plain ring having a height of 35 mm was measured using two spherical balls, each of diameter d = 25.000 mm. The ring was placed on a surface table and then both the balls were placed inside the ring. In this position, the height, h, of the top of the upper ball from the surface table was found to be 42.000 mm.
    (a) Derive the expression for D in terms of d and h.
    (b) What is the bore diameter, D, of the ring?

SECTION - A

1. This question consists of TWENTY-FIVE sub-questions (1.1 – 1.25) of ONE mark each. For each of these sub-questions, four possible alternatives (A, B, C and D) are given, out of which ONLY ONE is correct. Indicate the correct answer by darkening the appropriate bubble against the question number on the left hand side of the Objective Response Sheet (ORS). You may use the answer book provided for any rough work, if needed.

1.1 If Z = f(x,y), dz is equal to

(a) $\left(\frac{\partial f}{\partial x}\right)dx + \left(\frac{\partial f}{\partial y}\right)dy$ (b) $\left(\frac{\partial f}{\partial y}\right)dx + \left(\frac{\partial f}{\partial x}\right)dy$

(c) $\left(\frac{\partial f}{\partial x}\right)dx - \left(\frac{\partial f}{\partial y}\right)dy$ (d) $\left(\frac{\partial f}{\partial y}\right)dx - \left(\frac{\partial f}{\partial x}\right)dy$

1.2 $\underset{x\to 1}{Lt}\frac{\left(x^2-1\right)}{\left(x-1\right)}$ is:

(a) ∞ (b) 0 (c) 2 (d) 1

1.3 The solution of the differential equation $\frac{d^2y}{dx^2} + \frac{dy}{dx} + y = 0$ is

(a) $Ae^x + Be^{-x}$ (b) $e^x\left(Ax + B\right)$

(c) $e^{-x}\left\{A\cos\left(\frac{\sqrt{3}}{2}\right)x + B\cos\left(\frac{\sqrt{3}}{2}\right)x\right\}$ (d) $e^{\frac{-x}{2}}\left\{A\cos\left(\frac{\sqrt{3}}{2}\right)x + B\cos\left(\frac{\sqrt{3}}{2}\right)x\right\}$

1.4 The three characteristic roots of the following matrix A

$$A = \begin{bmatrix} 1 & 2 & 3 \\ 0 & 2 & 3 \\ 0 & 0 & 2 \end{bmatrix}$$ are

(a) 1, 2, 3 (b) 1, 2, 2 (c) 1, 0, 0 (d) 0, 2, 3

1.5 Availability of a system at any given state is

(a) a property of the system

(b) the maximum work obtainable as the system goes to dead state

(c) the total energy of the system

(d) the maximum useful work obtainable as the system goes to dead state

1.6 A steam turbine receives steam steadily at 10 bars with an enthalpy of 3000 kJ/kg and discharges at 1 bar with an enthalpy of 2700 kJ/kg. The work output is 250 kJ/kg. The changes in kinetic and potential energies are negligible. The heat transfer from the turbine casing to the surroundings is equal to

(a) 0 kJ (b) 50 kJ (c) 150 kJ (d) 250 kJ

1.7 In a vapour compression refrigeration system, liquid to suction heat exchanger is used to

(a) keep the COP constant

(b) prevent the liquid refrigerant from entering the compressor

(c) subcool the liquid refrigerant leaving the condensor

(d) subcool the vapour refrigerant from the evaporator

1.8 A steel steam pipe 10 cm inner diameter and 11 cm outer diameter is covered with an insulation having a thermal conductivity of 1 W/mK. If the convective heat transfer coefficient between the surface of insulation and the surrounding air is 8 W/m^2K, the critical radius of insulation is

(a) 10 cm (b) 11 cm (c) 12.5 cm (d) 15 cm

1.9 Which of the following is a pressure compounded turbine?

(a) Parsons (b) Curtis (c) Rateau (d) all the three

1.10 When the speed of a centrifugal pump is doubled, the power required to drive the pump will

(a) increase 8 times (b) increase 4 times

(c) double (d) remain the same

1.11 Global warming is caused by

(a) ozone (b) carbon dioxide

(c) nitrogen (d) carbon monoxide

1.12 Navier Strokes equation represents the conservation of

(a) energy (b) mass

(c) pressure (d) momentum

1.13 In a bi-axial stress problem, the stresses in x and y directions are $\sigma_x = 200\ MPa$ and $\sigma_y = 100\ MPa$. the maximum principal stress in MPa, is

(a) 50 (b) 100 (c) 150 (d) 200

1.14 The ratio of tension on the tight side to that on the slack side in a flat belt drive is:

(a) proportional to the product of coefficient of friction and lap angle

(b) an exponential function of the product of coefficient of friction and lap angle

(c) proportional to the lap angle

(d) proportional to the coefficient of friction

1.15 The natural frequency of an undamped vibrating system is 100 rad/s. A damper with a damping factor of 0.8 is introduced into the system. The frequency of vibration of the damped system, in rad/s, is

(a) 60 (b) 75 (c) 80 (d) 100

1.16 A steel shaft 'A' of diameter 'd' and length 'l' is subjected to a torque 'T'. Anohter shaft 'B' made of aluminium of the same diameter 'd' and length 0.5 l is alsos subjected to the same torque 'T'. The shear modulus of steel is 2.5 times the shear modulus of aluminium. The shear stress in the steel shaft is 100 MPa. The shear stress in the aluminium shaft, in MPa, is

(a) 40 (b) 50 (c) 100 (d) 250

1.17 A 1.5 kW motor is running at 1440 rev/min. It is to be connected to a stirrer running at 36 rev/min. The gearing arrangement suitable for this application is

(a) differential gear (b) helical gear

(c) spur gear (d) worm gear

1.18 A steel wheel of 600 mm diameter rolls on a horizontal steel rail. It carries a load of 500 N. The coefficient of rolling resistance is 0.3 mm. The force in N, necessary to roll the wheel along the rail is

(a) 0.5 (b) 5 (c) 15 (d) 150

1.19. Abrasive material used in grinding wheel selected for grinding ferrous alloys is:

(a) silicon carbide (b) diamond

(c) aluminium oxide (d) boron carbide

1.20. Cast steel crankshaft surface is hardened by

(a) nitriding (b) normalizing

(c) carburising (d) induction heating

1.21. Disposable patterns are made of

(a) wood (b) rubber (c) metal (d) polystyrene

1.22. Deep hole drilling of small diameter, say 0.2 mm is done with EDM by selecting the tool material as

(a) copper wire (b) tungsten wire
(c) brass wire (d) tungsten carbide

1.23. In computer aided drafting practice, an arc is defined by

(a) two end points only (b) center and radius
(c) radius and one end point (d) two end points and centre

1.24. In a time study exercise, the time observed for an activity was 54 seconds. The operator had a performance rating of 120. A personal time allowance of 10% is given. The standard time for the activity, in seconds, is

(a) 54 (b) 60.8 (c) 72 (d) 58.32

1.25 Cellular manufacturing is suitable for

(a) a single product in large volumes
(b) one-off production of several varieties
(c) products with similar features made in batches
(d) large variety of products in large volumes.

2. This question consists of TWENTY-FIVE sub-questions (2.1 – 2.25) of TWO marks each. For each of these sub-questions, four possible alternatives (A, B, C and D) are given, out of which ONLY ONE is correct. Indicate the correct answer by darkening the appropriate bubble against the question number on the left hand side of the Objective Response Sheet (ORS). You may use the answer book provided for any rough work, if needed.

2.1 The Laplace transform of the function $\sin^2 2t$ is:

(a) $\dfrac{\left(\frac{1}{2s}\right)-s}{\left[2\left(s^2+16\right)\right]}$ (b) $\dfrac{s}{\left(s^2+16\right)}$

(c) $\dfrac{\left(\frac{1}{s}\right)-s}{\left(s^2+4\right)}$ (d) $\dfrac{s}{\left(s^2+4\right)}$

2.2. The maximum value of the directional derivative of the function

$\phi = 2x^2 + 3y^2 + 5z^2$ at a point (1,1,-1) is

(a) 10 (b) -4 (c) $\sqrt{152}$ (d) 152

2.3. $\int_0^{\frac{\pi}{2}}\int_0^{\frac{\pi}{2}} \sin(x+y)\,dxdy$ is:

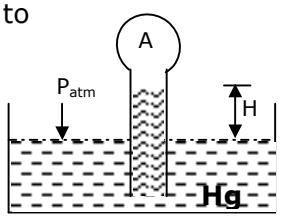
(a) 0 (b) π (c) $\frac{\pi}{2}$ (d) 2

2.4. In a manufacturing plant, the probability of making a defective bolt is 0.1. The mean and standard deviation of defective bolts in a total of 900 bolts are respectively

(a) 90 and 9 (b) 9 and 90 (c) 81 and 9 (d) 9 and 81

2.5. In Fig.2.5 if the pressure of gas in bulb A is 50 cm Hg vacuum and $p_{atm} = 76$ cm Hg, the height of column H is equal to

(a) 26 cm
(b) 50 cm
(c) 76 cm
(d) 126 cm



2.6. For a compressible fluid, sonic velocity is

(a) a property of the fluid

(b) always given by $(\gamma RT)^{\frac{1}{2}}$, where γ, R and T are respectively the ratio of specific heats, gas constant and temperature in K

(c) always given by $\left(\frac{\partial p}{\partial \rho}\right)_s^{\frac{1}{2}}$ where p, ρ and s are respectively pressure, density and entropy.

(d) always greater than the velocity of fluid at any location.

2.7. When an ideal gas with constant specific heats is throttled adiabatically, with negligible changes in kinetic and potential energies

(a) $\Delta h = 0, \Delta T = 0$ (b) $\Delta h > 0, \Delta T = 0$

(c) $\Delta h > 0, \Delta s > 0$ (d) $\Delta h = 0, \Delta s > 0$

where h, T and s represent respectively, enthalpy, temperature and entropy.

2.8. When atmospheric air is heated at constant pressure, its

(a) humidity ratio does not change
(b) relative humidity increases
(c) dew point temperature does not change
(d) wet bulb temperature increases

2.9. Consider air standard Otto and Diesel cycles, both having the same state of air at the start of compression. If the maximum pressure in both the cycles is the same, the compression ratio 'r' and the efficiency 'η' are related by

(a) $r_{Diesel} > r_{Otto}$ (b) $r_{Diesel} < r_{Otto}$ (c) $\eta_{Otto} > \eta_{Diesel}$ (d) $\eta_{Otto} < \eta_{Diesel}$

2.10. Air enters a counter-flow heat exchanger at 70°C and leaves at 40°C. Water enters at 30°C and leaves at 50°C. The LMTD in deg. C is

(a) 5.65 (b) 4.43 (c) 19.52 (d) 20.17

2.11. A fuel represented by the formula C_8H_{16} is used in an I.C. Engine. Given that the molecular weight of air is 29 and that 4.76 kmols of air contain 1 kmol of oxygen and 3.76 kmols of nitrogen, the Air/Fuel ratio by mass is

(a) 11.47 (b) 12.78 (c) 14.79 (d) 19.52

2.12. For the following "Matching" exercise, choose the correct one from among the alternatives A, B, C, and D.

Group 1	Group 2
1. Marine Diesel Engine	(a) Two stroke engine
2. Air conditioning	(b) Four stroke engine
3. Steam Power Plant	(c) Rotary engine
4. Gas Turbine Power Plant	(d) Cooling and dehumidification
	(e) Cooling tower
	(f) Brayton cycle
	(g) Rankine cycle
	(h) D-slide valve

(a) 1 – b 2 – e 3 – f 4 - h (b) 1 – c 2 – f 3 – e 4 - g

(c) 1 – c 2 – f 3 – g 4 - e (d) 1 – a 2 – d 3 – g 4 - f

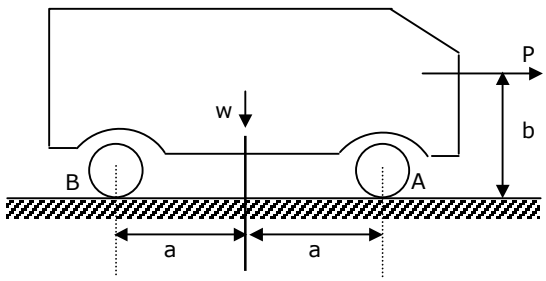
2.13. An automobile of weight W is shown in Fig.2.13. A pull 'P' is applied as shown. The reaction at the front wheels (location A) is

(a) $\frac{W}{2} - \frac{Pb}{2a}$

(b) $\frac{W}{2} + \frac{Pb}{2a}$

(c) $\frac{W}{2} - \frac{Pa}{2b}$

(d) $\frac{W}{2}$



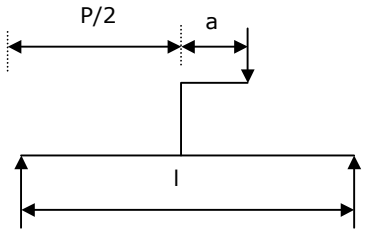
2.14. A simply supported beam carries a load 'P' through a bracket, as shown in Fig.2.14. The maximum bending moment in the beam is

(a) $\frac{Pl}{2}$

(b) $\frac{Pl}{2}+\frac{aP}{2}$

(c) $\frac{Pl}{2}+aP$

(d) $\frac{Pl}{2}-aP$



2.15. In an experiment to find the velocity and acceleration of a particular cam rotating at 10 rad/s, the values of displacements and velocities are recorded. The slope of displacement curve at an angle of 'θ' is 1.5 m/s and the slope of velocity curve at the same angle is –0.5 m/s^2. The velocity and acceleration of the cam at the instant are respectively.

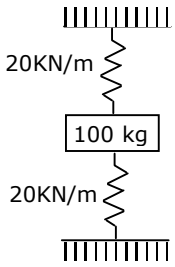
(a) 15 m/s and –5 m/s^2 (b) 15 m/s and 5 m/s^2

(c) 1.2 m/s and –0.5 m/s^2 (d) 1.2 m/s and 0.5 m/s^2

2.16. As shown in Fig.2.16, a mass of 100 kg is held between two springs. The natural frequency of vibration of the system, in cycles/s, is

(a) $\frac{1}{2\pi}$ (b) $\frac{5}{\pi}$

(c) $\frac{10}{\pi}$ (d) $\frac{20}{\pi}$



2.17. The life of a ball bearing at a load of 10 kN is 8000 hours. Its life in hours, if the load is increased to 20 kN, keeping all other conditions the same, is

(a) 4000 (b) 2000 (c) 1000 (d) 500

2.18. A fit is specified as 25 H8/e8. The tolerance value for a nominal diameter of 25 mm in IT8 is 33 microns and fundamental deviation for the shaft is –40 microns. The maximum clearance of the fit in microns is

(a) -7 (b) 7 (c) 73 (d) 106

2.19. A 1.5 mm thick sheet is subject to unequal biaxial stretching and the true strains in the directions of stretching are 0.05 and 0.09. The final thickness of the sheet in mm is

(a) 1.414 (b) 1.304 (c) 1.362 (d) 289

2.20. From an equilateral triangular plate of side 'a', a square plate of maximum size has to be cut. The side of such a square plate is:

(a) $\frac{\sqrt{3}a}{2}$ (b) $\frac{\left(2+\sqrt{3}\right)a}{4}$ (c) $\frac{\left(1+\sqrt{3}\right)a}{8}$ (d) $\frac{\sqrt{3}a}{\left(2+\sqrt{3}\right)}$

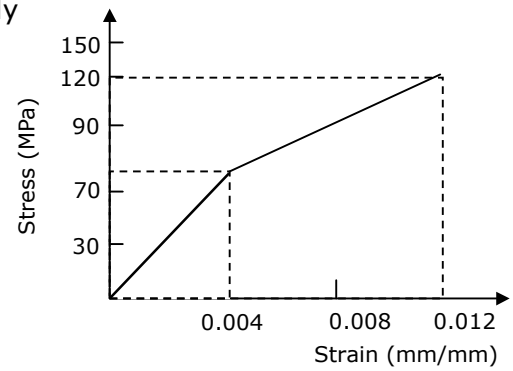
2.21. The stress-strain behaviour of a material is shown in Fig.2.21. Its resilience and toughness, in Nm/m^3, are respectively

(a) $28\times10^4, 76\times10^4$

(b) $28\times10^4, 48\times10^4$

(c) $14\times10^4, 90\times10^4$

(d) $76\times10^4, 104\times10^4$



2.22. A slot is to be milled centrally on a block with a dimension of 40 ± 0.05 mm. A milling cutter of 20 mm width is located with reference to the side of the block within ± 0.02 mm. The maximum offset in mm between the centerlines of the slot and the block is

(a) ± 0.070 (b) 0.070 (c) ± 0.020 (d) 0.045

2.23. In finish machining of an island on a casting with CNC milling machine, an end mill with 10 mm diameter is employed. The corner points of the island are represented by (0,0), (0,30), (50,30) and (50,0). By applying cutter radius right compensation, the trajectory of the cutter will be

(a) (-5,0), (-5,35), (55,35), (55,-5), (-5,-5)

(b) (0,-5), (55,-5), (55,35), (-5,35), (-5,-5)

(c) (5,5), (5,25), (45,25), (45,5), (5,5)

(d) (5,5), (45,5), (45,25), (5,25), (5,5)

2.24. In a single server infinite population queuing model, arrivals follow a Poisson distribution with mean λ = 4 per hour. The service times are exponential with mean service time equal to 12 minutes. The expected length of the queue will be

(a) 4 (b) 3.2 (c) 1.25 (d) 5

2.25. In a time series forecasting model, the demand for five time periods was 10, 13, 15, 18 and 22. A linear regression fit resulted in an equation F = 6.9 + 2.9 t where F is the forecast for period t. The sum of absolute deviations for the five data is:

(a) 2.2 (b) 0.2 (c) -1.2 (d) 24.3

SECTION – B

This section consists of TWENTY questions of FIVE marks each. Attempt ANY FIFTEEN questions. Answers must be given in the answer book provided. Answer for each question must start on a fresh page and must appear at one place only. (Answers to all parts of a question must appear together).

3. Estimate the root of the equation $\left(e^{-x} - x\right) = 0$ to four decimal accuracy by employing the Newton-Raphson method starting with an initial guess of $x_o = 0$.

4. A certain mass of a pure substance undergoes an irreversible process from state 1 to state 2, the path of the process being a straight line on the T-s diagram. Calculate the work interaction. Some of the properties at the initial and final states are:

   T_1=330 K, T_2=440 K, U_1 = 170 kJ, U_2 = 190 kJ, H_1 = 220 kJ, H_2 = 247 kJ and S_1 = 0.23 kJ/K and S_2 = 0.3 kJ/K, where T, U, H and S represent temperature, internal energy, enthalpy and entropy respectively.

5. A thin metal plate is exposed to solar radiation. The air and the surroundings are at 30°C. The heat transfer coefficient by free convection from the upper surface of the plate is 17.4 W/m^{2}K. The plate has an absorptivity of 0.9 at solar wavelength and an emissivity of 0.1 at the long wavelength. Neglecting any heat loss from the lower surface, determine the incident solar radiation intensity in kW/m^2, if the measured equilibrium temperature of the plate is 50°C. Stefan Boltzmann constant is 5.67×10^{-8} W/m^{2}K^4.

6. In an ideal air-standard Gas turbine cycle, the minimum and maximum temperatures are respectively 310 K and 1100 K. Draw the cycle on a T-s diagram and calculate the optimal pressure ratio of the cycle for maximum work output. Assume for air $\frac{(\gamma-1)}{\gamma}$ is 0.29 where γ is the ratio of specific heats.

7. A Diesel engine develops a Brake power of 4.5 kW. Its indicated thermal efficiency is 30% and the mechanical efficiency is 85%. Take the calorific value of the fuel as 40000 kJ/kg and calculate (a) the fuel consumption in kg/h and (b) the indicated specific fuel consumption.

8. A simple impulse turbine expands steam frictionlessly from 12 bar, 250°C with an enthalpy of 2935 kJ/kg to an enthalpy of 2584 kJ/kg at 0.1 bar. Assuming that the nozzle makes an angle of 20° with the blade motion, and that the blades are symmetrical, find the blade velocity that produces maximum efficiency for a turbine speed of 3600 rev/min. assume that the steam enters the nozzle with negligible velocity.

9. In a 5 kW cooling capacity refrigeration system operating on a simple vapour compression cycle, the refrigerant enters the evaporator with an enthalpy of 75 kJ/kg and leaves with an enthalpy of 183 kJ/kg. The enthalpy of the refrigerant after compression is 210 kJ/kg. Show the cycle on T-s or p-h diagram. Calculate the following:

   (a) COP

   (b) power input to compressor and

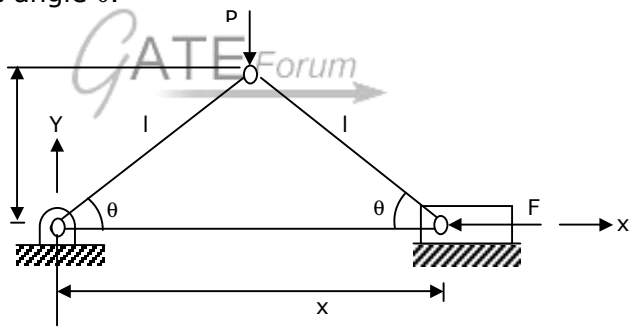
   (c) rate of heat transfer at the condenser.

10. A single acting single cylinder reciprocating air compressor running at 7.5 rev/s, takes in air at 100 k Pa, 27°C. The compressor delivers air at 600 k Pa at a flow rate of 0.12 m^3/s measured at suction conditions. Given that the percentage clearance is 4 and that the index of compression and expansion is 1.2. Calculate

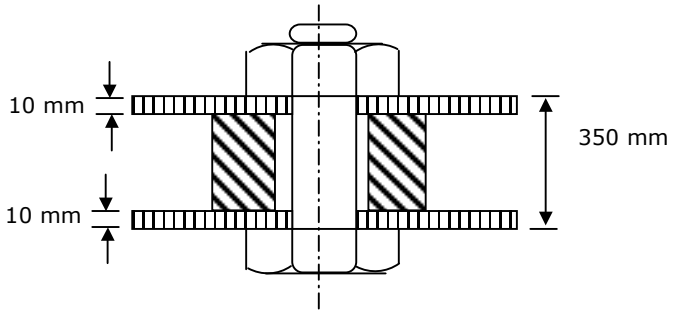
   (a) the ideal volumetric efficiency and

   (b) the cylinder bore and stroke, assuming the bore/stroke ratio is 0.8.

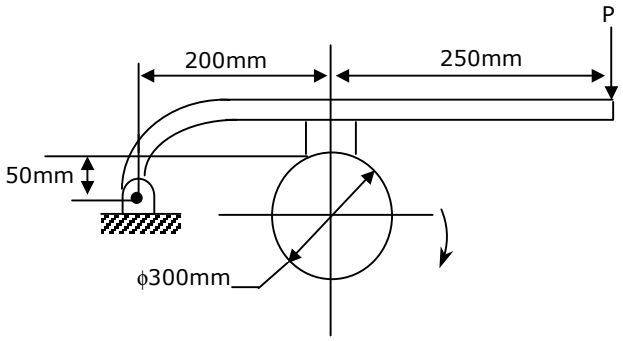
11. For the toggle device shown in Fig.11, derive the relationship between forces P and F in terms of the angle θ.



12. A steel bolt having a nominal diameter of 20 mm and a pitch of 2.4 mm is used to connect two plates of 10 mm thickness each. An aluminium tube of inner diameter 22 mm and outer diameter of 40 mm is separating the plates as shown in Fig.12. the nut is pulled snug (just tight) and then given a one-third additional turn. Find the resulting stresses in the bolt and the tube neglecting the deformation of the plates. Young's modulus of steel and aluminium are 207×10^3 MPa and 67.5×10^3 MPa respectively.



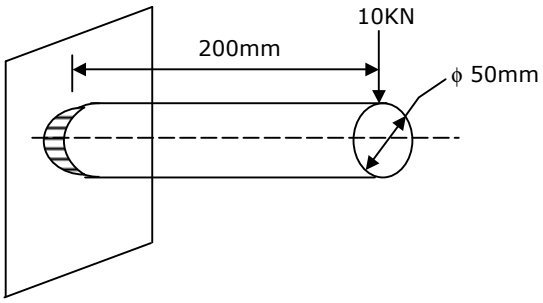
13. A single block brake with a 300 mm diameter brake down in Fig.13 is used to absorb a torque of 75 Nm. The coefficient of friction between the drum and the lining is 0.35. The pressure on the blocks is uniform. Calculate the force P.



14. A punch press, fitted with a flywheel having a radius of gyration of 0.5m, runs at 260 rev/min. the press is capable of punching 600 holes per hour. Each punching operation takes 1.5 seconds and requires a work of 10,000 Nm. The rating of the electric motor used is 2 kW. Determine the mass of the flywheel, if the speed of the flywheel should not drop below 240 rev/min.

15. A full journal bearing with a journal of 75 mm diameter and a bearing of 75 mm length is subjected to a radial load of 2500 N at 400 rev/min. The lubricant is SAE 30 at 75°C having a viscosity of 16.5×10^{-3} kg/ms. Radial clearance is 0.03 mm. Eccentricity of the bearing is 0.27. Find the Sommerfeld number and the minimum film thickness.

16. A circular rod 50 mm in diameter and 200 mm long is welded to a plate by fillet welding all around the circumference as shown in Fig.16. The size of the weld is 15mm. The section modulus of the weld is 22000 mm^3. Determine the resultant stress in the weld.



17. Two castings, a cube and a slab of the same material solidify under identical mould conditions. The volumes of the castings are equal but the slab dimensions are in the ratio of 1:2:4. Find the ratio of the solidification time of the cube to that of the slab.

18. A cylindrical billet of 100mm diameter is forged from 50 mm height to 40 mm at 1000°C. The material has a constant flow stress of 80 MPa.
    (a) Find the work of deformation.
    (b) If a 10 kN drop-hammer is used to complete the reduction in one blow, what will be the height of the fall?

19. A 15 mm diameter HSS drill is used at a cutting speed of 20 m/min and a feed rate of 0.2 mm/rev. under these conditions, the drill life is 100 min. the drilling length of each hold is 45 mm and the time taken for idle motions is 20s. the tool change time 300 s. calculate
    (a) number of holes produced using one drill and
    (b) average production time per hole.

20. A conventional lathe and a CNC lathe are under consideration for machining a given part. The relevant data are shown below.

	Preparation Cost (Rs)	Production time per part (min)	Machine and operator cost (Rs.)
Conventional Lathe	30	30	75
CNC Lathe	150	15	120

Find the break-even quantity, above which CNC lathe is economical.

21. Solve the following linear programming problem by simplex method.

Maximize $4x_1 + 6x_2 + x_3$

Subject to $2x_1 - x_2 + 3x_3 \le 5$

$x_1, x_2, x_3 \ge 0$

    (a) What is the solution to the above problem?
    (b) Add the constraint $x_2 \le 2$ to the simple table of part (a) and find the solution.

22. A company places orders for supply of two items A and B. The order cost for each of the items is Rs.300/order. The inventory carrying cost is 18% of the unit price per year per unit. The unit prices of the items are Rs.40 and Rs.50 respectively. The annual demands are 10,000 and 20,000 respectively.
    (a) Find the economic order quantities and the minimum total cost
    (b) A supplier is willing to give a 1% discount on price, if both the items are ordered from him and if the order quantities for each item are 1000 units or more. Is it profitable to avail the discount?

SECTION - A

1. This question consists of TWENTY-FIVE sub-questions (1.1 – 1.25) of ONE mark each. For each of these sub-questions, four possible alternatives (A, B, C and D) are given, out of which ONLY ONE is correct. Indicate the correct answer by darkening the appropriate bubble against the question number on the left hand side of the Objective Response Sheet (ORS). You may use the answer book provided for any rough work, if needed.

1.1 The divergence of vector $\vec{r} = x\vec{i} + y\vec{j} + z\vec{k}$ is

(a) $\vec{i} + \vec{j} + \vec{k}$ (b) 3 (c) 0 (d) 1

1.2 Consider the system of equations given below:

$$x + y = 2$$
$$2x + 2y = 5$$

This system has

(a) one solution (b) no solution
(c) infinite solutions (d) four solutions

1.3 What is the derivative of $f(z) = |x|$ at $x = 0$?

(a) 1 (b) -1
(c) 0 (d) Does not exist

1.4 The Gauss divergence theorem relates certain

(a) surface integrals to volume integrals
(b) surface integrals to line integrals
(c) vector quantities to other vector quantities
(d) line integrals to volume integrals

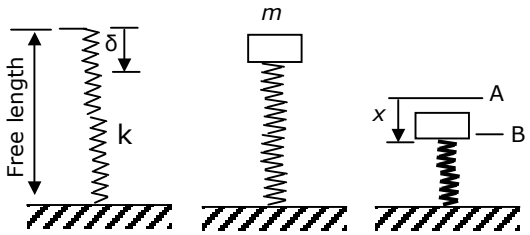
1.5 For a spring-loaded roller-follower driven with a disc cam,

(a) the pressure angle should be larger during rise than that during return for ease of transmitting motion
(b) the pressure angle should be smaller during rise than that during return for ease of transmitting motion
(c) the pressure angle should be large during rise as well as during return for ease of transmitting motion
(d) the pressure angle does not affect the ease of transmitting motion

1.6 The shape of the bending moment diagram for a uniform cantilever beam carrying a uniformly distributed load over its length is

(a) a straight line (b) a hyperbola
(c) a ellipse (d) a parabola

1.7 In the figure shown, the spring deflects by δ to position A (the equilibrium position) when a mass *m* is kept on it. During free vibration, the mass is at position B at some instant. The change in potential energy of the spring-mass system from position A to position B is

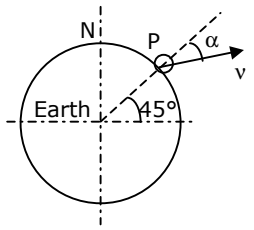


(a) $\frac{1}{2}kx^2$ (b) $\frac{1}{2}kx^2 - mgx$

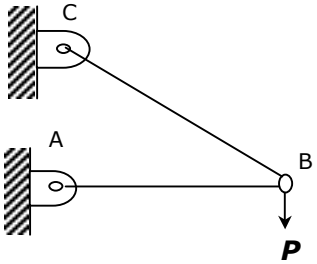
(c) $\frac{1}{2}k(x+\delta)^2$ (d) $\frac{1}{2}kx^2 + mgx$

1.8 A particle P is projected from the earth surface at latitude 45° with escape velocity v=11.19 km/s. the velocity direction makes an angle α with the local vertical. The particle will escape the earth's gravitational field

(a) only when α = 0
(b) only when α = 45°
(c) only when α = 90°
(d) irrespective of the value of α



1.9 Bars AB and BC, each of negligible mass, support load P as shown in the figure. In this arrangement,



(a) bar AB is subjected to bending but bar BC is not subjected to bending
(b) bar AB is not subjected to bending but bar BC is subjected to bending
(c) neither bar AB nor bar BC is subjected to bending
(d) both bars AB and BC are subjected to bending

1.10 The area moment of inertia of a square of size 1 unit about its diagonal is

(a) $\frac{1}{3}$ (b) $\frac{1}{4}$ (c) $\frac{1}{12}$ (d) $\frac{1}{6}$

1.11 Which of the following statement is correct?

(a) Flywheel reduces speed fluctuations during a cycle for a constant load, but flywheel does not control the mean speed of the engine if the load changes.

(b) Flywheel does not reduce speed fluctuation during a cycle for a constant load, but flywheel does not control the mean speed of the engine if the load changes.

(c) Governor controls speed fluctuations during a cycle for a constant load, but governor does not control the mean speed of the engine if the load changes.

(d) Governor controls speed fluctuations during a cycle for a constant load, and governor also control the mean speed of the engine if the load changes.

1.12 The SI unit of kinematic viscosity (ν) is

(a) m^2/sec (b) kg/(m-sec) (c) m/sec^2 (d) m^3/sec^2

1.13 A static fluid can have

(a) non-zero normal and shear stress

(b) negative normal stress and zero shear stress

(c) positive normal stress and zero shear stress

(d) zero normal stress and non-zero shear stress

1.14 A gas having a negative Joule-Thompson coefficient ($\mu < 0$), when throttled, will

(a) become cooler (b) become warmer

(c) remain at the same temperature

(d) either be cooler or warmer depending on the type of gas

1.15 Lumped heat transfer analysis of a solid object suddenly exposed to a fluid medium at a different temperature is valid when

(a) Biot number < 0.1 (b) Biot number > 0.1

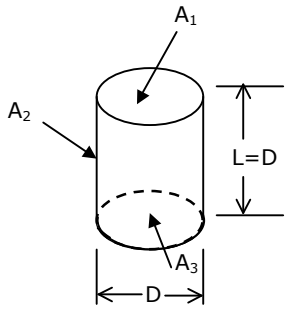
(c) Fourier number < 0.1 (d) Fourier number > 0.1

1.16 The Rateau turbine belongs to the category of

(a) pressure compounded turbine (b) reaction turbine

(c) velocity compounded turbine (d) radial flow turbine

1.17 For the circular tube of equal length and diameter shown below, the view factor F_{13} is 0.17. the view factor F_{12} in this case will be



(a) 0.17

(b) 0.21

(c) 0.79

(d) 0.83

1.18 In descending order of magnitude, the thermal conductivity of (a) pure iron, (b) liquid water, (c) saturated water vapour and (d) aluminum can be arranged as

(a) a b c d (b) b c a d (c) d a b c (d) d c b a

1.19. Shrinkage allowance on pattern is provided to compensate for shrinkage when

(a) the temperature of liquid metal drops from pouring to freezing temperature
(b) the metal changes from liquid to solid state at freezing temperature
(c) the temperature of solid phase drops from freezing to room temperature
(d) the temperature of metal drops from pouring to room temperature

1.20. The cutting force in punching and blanking operations mainly depends on

(a) the modulus of elasticity of metal (b) the shear strength of metal
(c) the bulk modulus of metal (d) the yield strength of metal

1.21. In ECM, the material removal is due to

(a) corrosion (b) erosion
(c) fusion (d) ion displacement

1.22. Two plates of the same metal having equal thickness are to be butt welded with electric arc. When the plate thickness changes, welding is achieved by

(a) adjusting the current (b) adjusting the duration of current
(c) changing the electrode size (d) changing the electrode coating

1.23. Allowance in limits and fits refers to

(a) maximum clearance between shaft and hole
(b) minimum clearance between shaft and hole
(c) difference between maximum and minimum size of hole
(d) difference between maximum and minimum size of shaft

1.24. Production flow analysis (PFA) is a method of identifying part families that uses data from

(a) engineering drawings (b) production schedule
(c) bill of materials (d) route sheets

1.25 When using a simple moving average to forecast demand, one would

(a) give equal weight to all demand data
(b) assign more weight to the recent demand data
(c) include new demand data in the average without discarding the earlier data
(d) include new demand data in the average after discarding some of the earlier demand data

2. This question consists of TWENTY-FIVE sub-questions (2.1 – 2.25) of TWO marks each. For each of these sub-questions, four possible alternatives (A, B, C and D) are given, out of which ONLY ONE is correct. Indicate the correct answer by darkening the appropriate bubble against the question number on the left hand side of the Objective Response Sheet (ORS). You may use the answer book provided for any rough work, if needed.

2.1 The minimum point of the function $f(x) = \left(x^3/3\right) - x$ is at

(a) x = 1 (b) x = -1 (c) x = 0 (d) $x = \frac{1}{\sqrt{3}}$

2.2. The rank of a 3×3 matrix C (= AB), found by multiplying a non-zero column matrix A of size 3×1 and a non-zero row matrix B of size 1×3, is

(a) 0 (b) 1 (c) 2 (d) 3

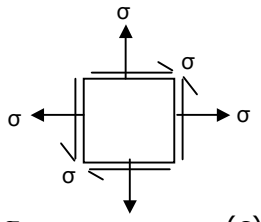
2.3. An unbiased coin is tossed three times. The probability that the head turns up in exactly two cases is

(a) $\frac{1}{9}$ (b) $\frac{1}{8}$ (c) $\frac{2}{3}$ (d) $\frac{3}{8}$

2.4. Two helical tensile springs of the same material and also having identical mean coil diameter and weight, have wire diameters d and $\frac{d}{2}$. The ratio of their stiffness is

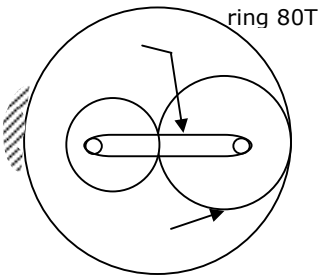
(a) 1 (b) 4 (c) 64 (d) 128

2.5. The maximum principal stress for the stress state shown in the figure is



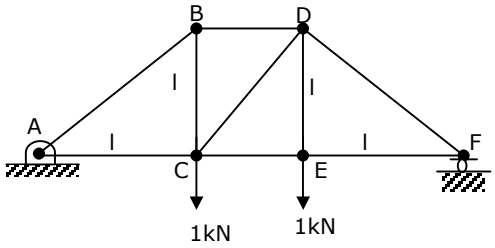
(a) σ (b) 2σ (c) 3σ (d) 1.5σ

2.6. The sun gear in the figure is driven clockwise at 100 rpm. The ring gear is held stationary. For the number of teeth shown on the gears, the arm rotates at



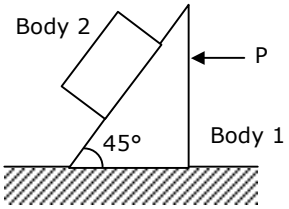
(a) 0 rpm (b) 20 rpm (c) 33.33 rpm (d) 66.67 rpm

2.7. For the loading on truss shown in the figure, the force in member CD is



(a) 0 kN (b) 1 kN (c) $\sqrt{2}$ kN (d) $\frac{1}{\sqrt{2}}$ kN

2.8. Bodies 1 and 2 shown in the figure have equal mass m. All surfaces are smooth. The value of force P required to prevent sliding of body 2 on body 1 is



(a) P = 2mg (b) P = $\sqrt{2}$ mg (c) P = $2\sqrt{2}$ mg (d) P = mg

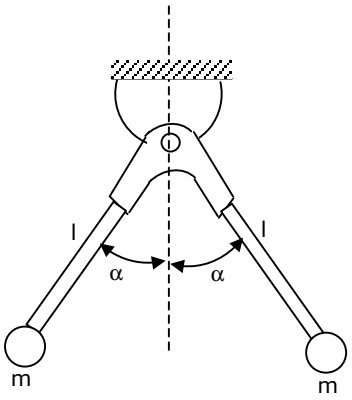
2.9. The assembly shown in the figure is composed of two massless rods of length l with two particles, each of mass m. the natural frequency of this assembly for small oscillations is

(a) $\sqrt{\frac{g}{l}}$

(b) $\sqrt{\frac{2g}{(l\cos\alpha)}}$

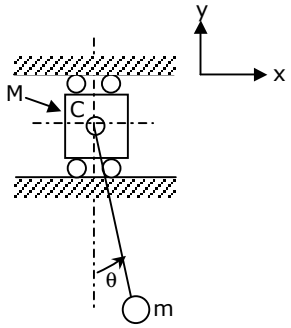
(c) $\sqrt{\frac{g}{(l\cos\alpha)}}$

(d) $\sqrt{\frac{(g\cos\alpha)}{l}}$



2.10. Mass M slides in a frictionless slot in the horizontal direction and the bob of mass m is hinged to mass M at C, through a rigid massless rod. This system is released from rest with θ =30°. At the instant when θ = 0, the velocities of m and M can be determined using the fact that, for the system (i.e., m and M together),

(a) the linear momentum in x and y directions are conserved but the energy is not conserved



(b) the linear momentum in x and y directions are conserved and the energy is also conserved

(c) the linear momentum in x direction is conserved and the energy is also conserved

(d) the linear momentum in y direction is conserved and the energy is also conserved

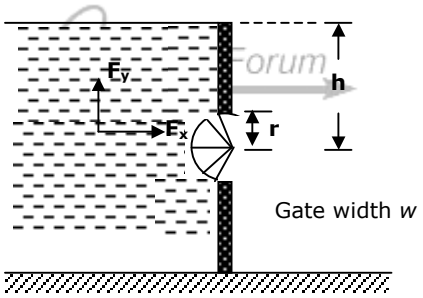
2.11. A cyclic heat engine does 50 kJ of work per cycle. If the efficiency of the heat engine is 75%, the heat rejected per cycle is

(a) $16\frac{2}{3}kJ$ (b) $33\frac{1}{3}kJ$ (c) $37\frac{1}{2}kJ$ (d) $66\frac{2}{3}kJ$

2.12. A single-acting two-stage compressor with complete intercooling delivers air at 16 bar. Assuming an intake state of 1 bar at 15°C, the pressure ratio per stage is

(a) 16 (b) 8 (c) 4 (d) 2

2.13. The horizontal and vertical hydrostatic forces F_x and F_y on the semi-circular gate, having a width ω into the plane of figure, are



(a) $F_x = \rho ghr\omega$ and $F_y = 0$ (b) $F_x = 2\rho ghr\omega$ and $F_y = 0$

(c) $F_x = \rho ghr\omega$ and $F_y = \rho g\omega r^2/2$ (d) $F_x = 2\rho ghr\omega$ and $F_y = \pi\rho g\omega r^2/2$

2.14. The 2-D flow with velocity $\vec{v} = (x + 2y + 2)\vec{i} + (4 - y)\vec{j}$ is

(a) compressible and irrotational (b) compressible and not irrotational

(c) incompressible and irrotational

(d) incompressible and not irrotational

2.15. A small steam whistle (perfectly insulated and doing no shaft work) causes a drop of 0.8 kJ/kg in the enthalpy of steam from entry to exit. If the kinetic energy of the steam at entry is negligible, the velocity of the steam at exit is

(a) 4 m/s (b) 40 m/s (c) 80 m/s (d) 120 m/s

2.16. For air at a given temperature, as the relative humidity is increased isothermally,

(a) the wet bulb temperature and specific enthalpy increase

(b) the wet bulb temperature and specific enthalpy decrease

(c) the wet bulb temperature increases and specific enthalpy decrease s

(d) the wet bulb temperature decreases and specific enthalpy increases

2.17. Water (Prandtl number $\simeq 6$) flows over a flat plate which is heated over the entire length. Which one of the following relationship between the hydrodynamic boundary layer thickness (δ) and the thermal boundary layer thickness (δ_t) is true?

(a) $\delta_t > \delta$ (b) $\delta_t < \delta$ (c) $\delta_t = \delta$

(d) Cannot be predicted

2.18. In a spark ignition engine working on the ideal Otto cycle, the compression ratio is 5.5. The work output per cycle (i.e., area of the P-V diagram) is equal to $23.625 \times 10^5 \times V_c$ J, where V_c is the clearance volume in m^3. The indicated mean effective pressure is

(a) 4.295 bar (b) 5.250 bar

(c) 86.870 bar (d) 106.300 bar

2.19. The height of the down-sprue is 175 mm and its cross-sectional area at the base is 200 mm^2. The cross-sectional area of the horizontal runner is also 200 mm^2. assuming no losses, indicate the correct choice for the time (in seconds) required to fill a mold cavity of volume 10^6 mm^3. (Use g = 10 m/s^2).

(a) 2.67 (b) 8.45 (c) 26.72 (d) 84.50

2.20. For rigid perfectly plastic work material, negligible interface friction and no redundant work, the theoretically maximum possible reduction in the wire drawing operation is

(a) 0.36 (b) 0.63 (c) 1.00 (d) 2.72

2.21. During orthogonal cutting of mild steel with a 10° rake angle tool the chip thickness ratio was obtained as 0.4. the shear angle (in degrees) evaluated from this data is

(a) 6.53 (b) 20.22 (c) 22.94 (d) 50.00

2.22. Resistance spot welding is performed on two plates of 1.5 mm thickness with 6 mm diameter electrode, using 15000 A current for a time duration of 0.25 seconds. Assuming the interface resistance to be 0.0001Ω, the heat generated to form the weld is

(a) 5625 W-sec (b) 8437 W-sec

(c) 22500 W-sec (d) 33750 W-sec

2.23. Fifty observations of a production operation revealed a mean cycle time of 10 min. the worker was evaluated to be performing at 90% efficiency. Assuming the allowances to be 10% of the normal time, the standard time (in seconds) for the job is

(a) 0.198 (b) 7.3 (c) 9.0 (d) 9.9

2.24. 3-2-1 method of location in a jig or fixture would collectively restrict the work piece in n degrees of freedom, where the value of n is

(a) 6 (b) 8 (c) 9 (d) 12

2.25. In an NC machining operation, the tool has to be moved from point (5,4) to point (7,2) along a circular path with center at (5,2). Before starting the operation, the tool is at (5,4). The correct G and M code for this motion is

(a) N010 G03 X7.0 Y2.0 I5.0 J2.0 (b) N010 G02 X7.0 Y2.0 I5.0 J2.0

(c) N010 G01 X7.0 Y2.0 I5.0 J2.0 (d) N010 G00 X7.0 Y2.0 I5.0 J2.0

SECTION – B

This section consists of TWENTY questions of FIVE marks each. Attempt ANY FIFTEEN questions. Answers must be given in the answer book provided.

3. Solve the differential equation,

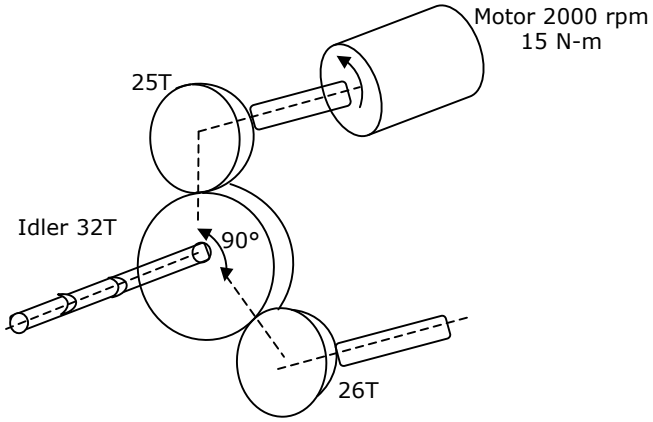
$$\frac{d^2y}{dx^2} + y = x$$

with the following conditions:

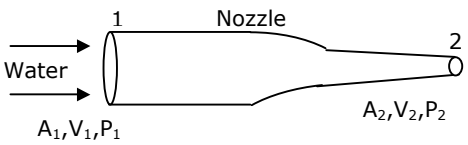
(i) at x = 0, y = 1

(ii) at $x = \frac{\pi}{2}$, $y = \frac{\pi}{2}$

4. The figure shows an electric motor driving a machine under steady conditions by means of three straight tooth spur gears having 25, 32 and 26 teeth. The diametral pitch is 4 teeth/cm and the pressure angle is 20°. For the direction of motor rottion shown, determine the radial load acting on the shaft carrying the idler.



5. Water (ρ = 1000 kg/m^3) flows horizontally through a nozzle into the atmosphere under the conditions given below. (assume steady state flow).



At inlet: $A_1 = 10^{-3}m^2$; V_1 = 2m/sec; $P_1 = 3\times10^5$ Pa(gauge)

At outlet: $A_1 = 10^{-4}m^2$; $P_2 = P_{atm}$

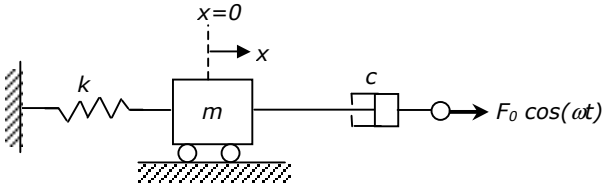
Determine the external horizontal force needed to keep the nozzle in place.

6. A number of cold rolling passes are required in a two-high rolling mill to reduce the thickness of a plate from 50 mm to 25 mm. The roll diameter is 700 mm and the coefficient of friction at the roll work interface is 0.1. it is required that the draft in each pass must be the same. Assuming no front and back tensions, determine (a) the minimum number of passes required and (b) the draft in each pass.

7. Steam at 300 kPa and 500°C (h = 3486.0 kJ/kg) enters a steam turbine and exits at atmospheric pressure and 350°C (h = 3175.8 kJ/kg). Heat losses in the turbine are 50 kW and the mass flow rate is 0.25 kg/s. determine the power output of the turbine if kinetic energy losses are negligible.

8. Two solid workpieces, (i) a sphere with radius R and (ii) a cylinder with diameter equal to its height, have to be sand cast. Both work-pieces have the same volume. Show that the cylindrical work-piece will solidify faster than the spherical work-piece.

9. A spring mass dashpot system is shown in the figure. The spring stiffness is k, mas is m, and the viscous damping coefficient is c. the system is subjected to a force $f_o\cos\omega t$ as shown. Write the equations of motion which are needed to determine x. (No need to determined x.)



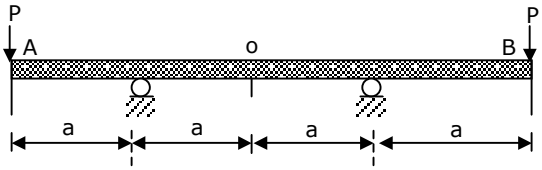
10. A four-stroke engine develops 18.5 kW at 250 rpm. The turning moment diagram is rectangular for both expansion and compression strokes. The turning moment is negative during compression stroke and is zero during suction and exhaust strokes. The turning moment for the expansion stroke is 2.8 times that of the compression stroke. Assuming constant load, determine the moment of inertia of the flywheel to keep the total fluctuation of the crankshaft speed within 1% of the average speed of 250 rpm.

11. Use the area moment method to find the vertical deflection of the uniform beam AB at the following points:

    (a) middle of the beam (point O)

    (b) left end of the beam (point A)

    The flexural rigidity of the beam is EI.

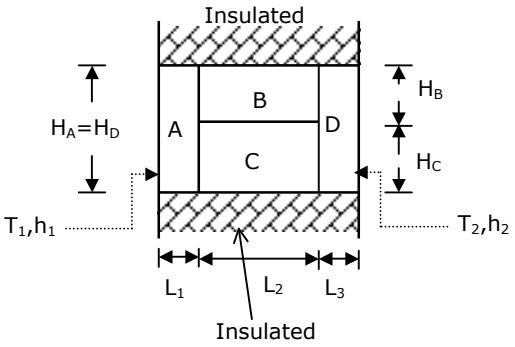


12. Tool life testing on a lathe under dry cutting conditions gave n and C of Taylor tool life equation as 012 and 130 m/min, respectively. When a coolant was used, C increased by 10%. Find the percent increase in tool life with the use of coolant at a cutting speed of 90 m/min.

13. Identical straight turning operation was carried out using two tools: 8-8-5-5-5-25-0 (ASA) and 8-8-5-5-7-30-0 (ASA). Show that the first tool will give better surface finish in terms of peak-to-valley height.

14. Water flows through a 0.6 m diameter, 1000 m long pipe from a 30 m overhead tank to a village. Find the discharge (in liters) at the village (at ground level), assuming a Fanning friction factor f = 0.04 and ignoring minor losses due to bends etc.

15. A composite wall, having unit length normal to the plane of paper, is insulated at the top and bottom as shown in the figure. It is comprised of four different materials A, B, C and D.



The dimensions are: $H_A = H_D = 3m$, $H_B = H_C = 1.5$ m, $L_1 = L_3 = 0.05m$, $L_2 = 0.1$ m

The thermal conductivity of the materials are: $K_A = K_D = 50$ W/m-K, $K_B = 10$W/m-k, $K_C = 1$ W/m-k.

The fluid temperatures and heat transfer coefficients (see figure) are: $T_1 = 200°C$, $h_1 = 50$ W/m^2-K, $T_2 = 25°C$, $h_2 = 10$ W/m^2–K.

Assuming one-dimensional conduction,

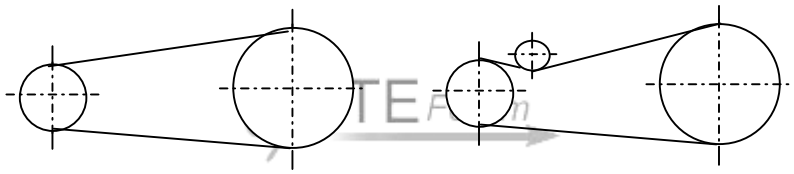
(a) sketch the thermal circuit of the system, and

(b) determine the rate of heat transfer through the wall.

16. A Brayton cycle (air standard) has a pressure ratio of 4 and inlet conditions of one standard atmosphere pressure and 27°C. Find the air flow rate required for 100 kW power output if the maximum temperature in the cycle is 1000°C. Assume γ=1.4 and C_p = 1.0 kJ/kg-K.

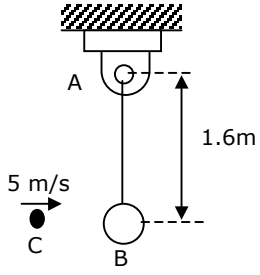
17. A Francis turbine running at 200 rpm develops a power of 5000 kW under a head of 25 m. determine the speed and power output under a head of 100 m.

18. A belt drive shown in Figure (a) has an angle of wrap of 160° on the smaller pulley. Adding an idler as shown in Figure (b), increases the wrap angle to 200°. The slack side tension is the same in both cases and the centrifugal force is negligible. By what percentage is the torque capacity of the belt drive increased by adding the idler? (use coefficient of friction μ = 0.3.)



(a) (b)

19. The 2 kg mass C moving horizontally to the right, with a velocity of 5 m/s, strikes the 8 kg mass B at the lower end of the rigid massless rod AB. The rod is suspended from a frictionless hinge at A and is initially at rest. If the coefficient of restitution between mass C and mass B is one, determine the angular velocity of the rod AB immediately after impact.



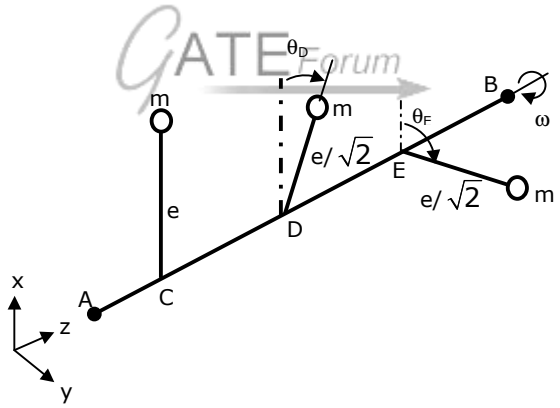
20. A mechanic has an engine from a 1970 model car which works on the basis of Otto cycle. The engine displaces 1.8 liters, has a compression ratio of 10.2:1 and has six cylinders. The pistons in the original engine are 120 mm in diameter. The mechanic bores the cylinder and replaces the piston with new pistons that are 2 mm larger in diameter than the originals. (a) Keeping all other factors same, what will be the percentage change in power output? (b) By what percentage will the engine efficiency change?

21. A company is offered the following price breaks for order quantity

Order quantity	Price (Rs.)
0 – 100	150
101 and above	100

Order cost is Rs.60 per order while the holding cost is 10% of the purchase price. Determine the economic order quantity (EOQ) if the annual requirement is 1000 units.

22. The shaft shown is supported on bearings at A and B. This shaft carries three eccentric masses (each of mass m) in planes parallel to x-y plane at C, D and E. the eccentricity of mass at C is e and eccentricity of masses at D and E is $\frac{e}{\sqrt{2}}$. the shaft rotates at speed ω. In the figure, θ_D and θ_E indicate the angular positions of masses at D and E in x-y plane with respect to that of mass at C. Neglecting gravity effect, determine θ_D and θ_E to provide static balance. Also determine the ratio of magnitudes of dynamic bearing reactions at A and B for the obtained values of θ_D and θ_E.



SECTION - A

1. This question consists of TWENTY-FIVE sub-questions (1.1 – 1.25) of ONE mark each. For each of these sub-questions, four possible alternatives (A, B, C and D) are given, out of which ONLY ONE is correct. Indicate the correct answer by darkening the appropriate bubble against the question number on the left hand side of the Objective Response Sheet (ORS). You may use the answer book provided for any rough work, if needed.

1.1 Two dice are thrown. What is the probability that the sum of the numbers on the two dice is eight?

(a) $\frac{5}{36}$ (b) $\frac{5}{18}$ (c) $\frac{1}{4}$ (d) $\frac{1}{3}$

1.2 Which of the following functions is not differentiable in the domain [-1,1]?

(a) $f(x)=x^2$ (b) $f(x)=x-1$

(c) $f(x)=2$ (d) $f(x)=\text{maximum}(x,-x)$

1.3 A regression model is used to express a variable Y as a function of another variable X. this implies that

(a) there is a causal relationship between Y and X

(b) a value of X may be used to estimate a value of Y

(c) values of X exactly determine values of Y

(d) there is no causal relationship between Y and X

1.4 The principles of motion economy are mostly used while conducting

(a) a method study on an operation

(b) a time study on an operation

(c) a financial appraisal of an operation

(d) a feasibility study of the proposed manufacturing plant

1.5 The standard time of an operation while conducting a time study is

(a) mean observed time + allowances

(b) normal time + allowances

(c) mean observed time $\times$ rating factor + allowances

(d) normal time $\times$ rating factor + allowances

1.6 In carrying out a work sampling study in a machine shop, it was found that a particular lathe was down for 20% of the time. What would be the 95% confidence interval of this estimate if 100 observations were made?

(a) (0.16,0.24) (b) (0.12,0.28) (c) (0.08,0.32) (d) none of these

1.7 An item can be purchased for Rs.100. The ordering cost is Rs.200 and the inventory carrying cost is 10% of the item cost per annum. If the annual demand is 4000 units, the economic order quantity (in units) is

(a) 50 (b) 100 (c) 200 (d) 400

1.8 The minimum number of teeth on the pinion to operate without interference in standard full height involute teeth gear mechanism with 20° pressure angle is

(a) 14 (b) 12 (c) 18 (d) 32

1.9 The minimum number of links in a single degree-of-freedom planar mechanism with both higher and lower kinematic pairs is

(a) 2 (b) 3 (c) 4 (d) 5

1.10 The Coriolis component of acceleration is present in

(a) 4-bar mechanisms with 4 turning pairs (b) shape mechanism
(c) slider-crank mechanism (d) Scotch Yoke mechanism

1.11 The total area under the stress-strain curve of a mild steel specimen tested up to failure under tension is a measure of

(a) ductility (b) ultimate strength
(c) stiffness (d) toughness

1.12 The number of components in a stress tensor defining stress at a point in three dimensions is

(a) 3 (b) 4 (c) 6 (d) 9

1.13 A lead-screw with half nuts in a lathe, free to rotate in both directions has

(a) V-threads (b) Whitworth threads
(c) Buttress threads (d) Acme threads

1.14 the primary purpose of a sprue in a casting mould is to

(a) feed the casting at a rate consistent with the rate of solidification
(b) act as a reservoir for molten metal
(c) feed molten metal from the pouring basin to the gate
(d) help feed the casting until all solidification takes place

1.15 Hot rolling of mild steel is carried out

(a) at re-crystallization temperature (b) between 100 C to 150 C
(c) between re-crystallization temperature
(d) above re-crystallization temperature

1.16 Which of the following arc welding processes does not use consumable electrodes
(a) GMAW (b) GTAW
(c) Submerged Arc Welding (d) none of these

1.17 Trepanning is performed for
(a) finishing a drilled hole
(b) producing a large hole without drilling
(c) truing a hole for alignment (d) enlarging a drilled hole

1.18 The hardness of a grinding wheel is determined by the
(a) hardness of abrasive grains
(b) ability of the bond to retain abrasives
(c) hardness of the bond
(d) ability of the grinding wheel to penetrate the work piece

1.19 A positive value of Joule-Thomson coefficient of a fluid means
(a) temperature drops during throttling
(b) temperature remains constant during throttling
(c) temperature rises during throttling
(d) none of these

1.20 If there are m physical quantities and n fundamental dimensions in a particular process, the number of non-dimensional parameters is
(a) $m+n$ (b) $m \times n$ (c) $m-n$ (d) m/n

1.21 If x is the distance measured from the leading edge of a flat plate, the laminar boundary layer thickness varies as
(a) $\frac{1}{x}$ (b) $x^{\frac{4}{5}}$ (c) x^2 (d) $x^{\frac{1}{2}}$

1.22 Flow separation in flow past a solid object is caused by
(a) a reduction of pressure to vapour pressure
(b) a negative pressure gradient
(c) a positive pressure gradient
(d) the boundary layer thickness reducing to zero

1.23 A correctly designed convergent-divergent nozzle working at a designed load is
(a) always isentropic (b) always choked
(c) never choked (d) never isentropic

1.24 The value of Biot number is very small (less than 0.01) when

(a) the convective resistance of the fluid is negligible

(b) the conductive resistance of the fluid is negligible

(c) the conductive resistance of the solid is negligible

(d) none of these

1.25 For the same inlet and outlet temperatures of hot and cold fluids, the Log Mean Temperature Difference (LMTD) is

(a) greater for parallel flow heat exchanger than for counter flow heat exchanger.

(b) greater for counter flow heat exchanger than for parallel flow heat exchanger.

(c) same for both parallel and counter flow heat exchangers.

(d) dependent on the properties of the fluids.

2. This question consists of TWENTY-FIVE sub-questions (2.1 – 2.25) of TWO marks each. For each of these sub-questions, four possible alternatives (A, B, C and D) are given, out of which ONLY ONE is correct. Indicate the correct answer by darkening the appropriate bubble against the question number on the left hand side of the Objective Response Sheet (ORS). You may use the answer book provided for any rough work, if needed.

2.1 The following set of equations has

$$3x + 2y + z = 4$$
$$x - y + z = 2$$
$$-2x + 2z = 5$$

(a) no solution

(b) a unique solution

(c) multiple solutions

(d) an inconsistency

2.2 The function $f(x,y) = 2x^2 + 2xy - y^3$ has

(a) only one stationary point at (0,0)

(b) two stationary points at (0,0) and $\left(\frac{1}{6},\frac{1}{3}\right)$

(c) two stationary points at (0,0) and (1,-1)

(d) no stationary point

2.3 Manish has to travel from A to D changing buses at stops B and C enroute. The maximum waiting time at either stop can be 8 minutes each, but any time of waiting up to 8 minutes is equally likely at both places. He can afford up to 13 minutes of total waiting time if he is to arrive at D on time. What is the probability that Manish will arrive late at D?

(a) $\frac{8}{13}$ (b) $\frac{13}{64}$ (c) $\frac{119}{128}$ (d) $\frac{9}{128}$

2.4 Arrivals at a telephone booth are considered to be Poisson, with an average time of 10 minutes between successive arrivals. The length of a phone call is distributed exponentially with mean 3 minutes. The probability that an arrival does not have to wait before service is

(a) 0.3 (b) 0.5 (c) 0.7 (d) 0.9

2.5 The supply at three sources is 50, 40 and 60 units respectively whilst the demand at the four destinations is 20, 30, 10 and 50 units. In solving this transportation problem

(a) a dummy source of capacity 40 units is needed

(b) a dummy destination of capacity 40 units is needed

(c) no solution exists as the problem is infeasible

(d) none solution exists as the problem is degenerate

2.6 A project consists of three parallel paths with mean durations and variances of (10,4), (12,4) and (12,9) respectively. According to the standard PERT assumptions, the distribution of the project duration is

(a) Beta with mean 10 and standard deviation 2

(b) Beta with mean 12 and standard deviation 2

(c) Normal with mean 10 and standard deviation 3

(d) Normal with mean 12 and standard deviation 3

2.7 The coupling used to connect two shafts with large angular misalignment is

(a) a Flange coupling (b) an Oldham's coupling

(c) a Flexible bush coupling (d) a Hooke's joint

2.8 A static load is mounted at the center of a shaft rotating at uniform angular velocity. This shaft will be designed for

(a) the maximum compressive stress (static)

(b) the maximum tensile (static)

(c) the maximum bending moment (static)

(d) fatigue loading

2.9 Large speed reductions (greater than 20) in one stage of a gear train are possible through

(a) Spur gearing (b) Worm gearing

(c) Bevel gearing (d) Helical gearing

2.10 If the wire diameter of a closed coil helical spring subjected to compressive load is increased from 1 cm to 2 cm, other parameters remaining same, the deflection will decrease by a factor of

(a) 16 (b) 8 (c) 4 (d) 2

2.11 The relationship between Young's modulus (E), Bulk modulus (K) and Poisson's ratio (μ) is given by

(a) $E = 3K(1-2\mu)$ (b) $K = 3E(1-2\mu)$ (c) $E = 3K(1-\mu)$ (d) $K = 3E(1-\mu)$

2.12 The ratio of Euler's buckling loads of columns with the same parameters having (i) both ends fixed, and (ii) both ends hinged is

(a) 2 (b) 4 (c) 6 (d) 8

2.13 If the length of the cantilever beam is halved, the natural frequency of the mass M at the end of this cantilever beam of negligible mass is increased by a factor of

(a) 2 (b) 4 (c) $\sqrt{8}$ (d) 8

2.14 In centrifugal casting, the impurities are

(a) uniformly distributed (b) forced towards the outer surface
(c) trapped near the mean radius of the casting
(d) collected at the center of the casting

2.15 The ductility of a material with work hardening

(a) increases (b) decreases
(c) remains unaffected (d) unpredictable

2.16 The temperature of a carburising flame in gas welding is _____ that of a neutral or an oxidizing flame.

(a) lower than (b) higher than (c) equal to (d) unrelated to

2.17 In a blanking operation, the clearance is provided on

(a) the die (b) both the die and the punch equally
(c) the punch (d) neither the punch nor the die

2.18 A built-up-edge is formed while machining

(a) ductile materials at high speed (b) ductile materials at low speed
(c) brittle materials at high speed (d) brittle materials at low speed

2.19 The time taken to drill a hole though a 25 mm thick plate with the drill rotating at 300 rpm and moving at a feed rate of 0.25 mm/revolution is

(a) 10 sec (b) 20 sec (c) 60 sec (d) 100 sec

2.20 The properties of mercury at 300 K are: density = 13529 kg/m^3, specific heat at constant pressure = 0.1393 kJ/kg-K, dynamic viscosity =0.1523×10^{-2} N.s/m^2 and thermal conductivity =8.540 W/m-K. The Prandtl number of the mercury at 300 K is

(a) 0.0248 (b) 2.48 (c) 24.8 (d) 248

2.21 What is the value of the view factor for two inclined flat hving common edge of equal width, and with an angle of 20 degrees?

(a) 0.83 (b) 1.17 (c) 0.66 (d) 1.34

2.22 A Carnot cycle is having an efficiency of 0.75. If the temperature of the high temperature reservoir is 727 C, what is the temperature of low temperature reservoir?

(a) 23 C (b) -23 C (c) 0 C (d) 250 C

2.23 An ideal air standard Otto cycle has a compression ratio of 8.5. If the ratio of the specific heats of air (γ) is 1.4, what is the thermal efficiency (in percentage) of the Otto cycle?

(a) 57.5 (b) 45.7 (c) 52.5 (d) 95

2.24 What is the speed of sound in Neon gas at a temperature of 500K (Gas constant of Neon is 0.4210 kJ/kg-K)?

(a) 492 m/s (b) 460 m/s (c) 592 m/s (d) 543 m/s

2.25 The efficiency of superheat Rankine cycle is higher than that of simple Rankine cycle because

(a) the enthalpy of main steam is higher for superheat cycle

(b) the mean temperature of heat addition is higher for superheat cycle

(c) the temperature of steam in the condenser is high

(d) the quality of steam in the condenser is low

SECTION – B

This section consists of TWENTY questions of FIVE marks each. Attempt ANY FIFTEEN questions. Answers must be given in the answer book provided.

3. Using Laplace transform, solve

$d^2y/dt^2 + 4y = 12t$

given that y = 0 and $dy/dt = 9$ at t = 0.

4. A tube of 35 mm outside diameter was turned on a lathe and the following data was obtained:

Rake angle = 35°	Cutting speed	= 15 m/min
Feed rate = 0.1mm/rev	Length of continuous chip in one revolution	=60 mm
Cutting force = 2000 N	Feed force	= 800 N

Calculate the chip thickness, shear plane angle, velocity of chip along tool face and coefficient of friction.

5. While measuring the effective diameter of an external metric screw thread gauge of 3.5mm pitch, a 30.5 mm diameter cylindrical standard and 2 mm diameter wires were used. The micrometer reading over the standard and wires was 13.3768 mm. The corresponding reading over the thread gauge and wires was 12.2428 mm.

Calculate the thread gauge effective diameter.

6. The arc length-voltage characteristic of a D.C. arc is given by the equation V =24+4L where V is the arc voltage in volts and L is the arc length in mm. The static volt-ampere characteristic of the power source is approximated by a straight line with a no load voltage of 80 Volts and short circuit current of 600 Amperes. Determine the optimum arc length for maximum power.

7. Estimate the metal removal rate (in cc/hr) of an alloy containing 18% Cobalt, 62% Nickel and 20% Chromium during Electro-Chemical Machining (ECM) with a current of 500 Amperes. The density of the alloy is 8.28 gm/cc. The following data is available:

Metal	Gram Atomic Weight	Valency
Cobalt	58.93	2
Nickel	58.71	2
Chromium	51.99	6
Assume Faraday's constant as 96,500 Coulombs/mole		

8. A chalk stick is twisted to failure by applying opposite torques T at the two ends. Take a square elements ABCD with two sides parallel to the longitudinal axis of the stick.
   (a) Show the free body diagram with principal stresses.
   (b) Find out the principal stresses σ_1 and σ_2 and the principal planes.
   (c) Show the plane on which failure/fracture will take place.

9. A cantilever AB of length 'L' has fixed end A and free end B. It is loaded by applying a concentrated load W at the mid point C of the cantilever.
   (a) Determine the deflection and slope at points C and B.
   (b) Show deflections and slopes on the cantilever.

10. In a single degree-of-freedom, 4-link, revolute jointed Grashoff mechanism, 'l' is the longest link, 's' is the shortest link and p,q are the two remaining links. These links may be in any order.
   (a) Write down the condition for feasibility of Grashoff mechanism.
   (b) When will you get crank-crank, crank-rocker and rocker-rocker type of mechanisms by fixing links s,l,p or q respectively?
   (c) Draw these mechanisms showing motions of crank and rocker links.

11. A toy cylinder of weight w, length l, and radius r rolls without slipping on the inner cylindrical surface of radius R, which is fixed.
   (a) Determine the differential equation of motion of the toy for large oscillation about its lowest point using energy method.
   (b) Write down the equation of motion and circular frequency of oscillation of the toy for small oscillations.

   The center of gravity of the toy is assumed to be at the center of the toy cylinder.

12. A hollow mild steel shaft is subjected to torsional and bending moments T and M respectively. The outside and inside diameters of the shaft are D and d respectively.
   (a) Derive the expressions for the maximum shear stress, and the maximum normal stress induced due to combined T and M.
   (b) Name any one theory of failure, which may be used to design this shaft using these stresses.

13. A company has introduced a new product with fixed cost of Rs.200 per week and unit variable cost of Rs.7. The product is sold to a retailer with a quantity discount as per the following schedule:

Quantity	Unit price
0 – 99 units	Rs.10
100 units onwards	Rs.8

(a) Determine the profit as a function of quantity sold.

(b) In what range of quantities sold does the company earn profit?

14. A furniture manufacturer produces chairs and tables. The wood-working department is capable of producing 200 chairs or 100 tables or any proportionate combinations of these per week. The weekly demand for chairs and tables is limited to 150 and 80 units respectively. The profit from a chair is Rs.100 and that from a table is Rs.300.

(a) Set up the problem as a Linear Program

(b) Determine the optimum product mix for maximizing the profit.

(c) What is the maximum profit?

(d) If the profit of each table drops to Rs.200 per unit, what is the optimal mix and profit?

15. The precedence relations and durations of jobs in a project are given below:

Job	Predecessor(s)	Duration (in days)
A	-	2
B	-	4
C	A	6
D	A	8
E	B,C	6
F	B,C	4
G	F	2
H	F	8
I	D,E,G	6

(a) Draw the activity-on-arc project network

(b) Determine all critical path(s) and their duration(s).

(c) What is the total float for jobs B and D?

16. A copper tube of 20 mm outer diameter, 1 mm thickness and 20 m long (Thermal conductivity = 400 W/m-K) is carrying saturated steam at 150 C (Convective heat transfer coefficient = 150 W/m^2-K). The tube is exposed to an ambient temperature of 27 C. The convective heat transfer coefficient of air is 5 W/m^2-K. Glass wool is used for insulation (Thermal conductivity = 0.075 W/m-K). If the thickness of the insulation used is 5 mm higher than the critical thickness of insulation, calculate the rate of heat lost by the steam and the rate of steam condensation in kg/hr (The enthalpy of condensation of steam = 2230 kJ/kg).

17. Air at 327 C and 400 kPa with a volume flow rate of 5 m^3/s flows through a turbine and exits at 100 kPa and 182 C.

    If the expansion process is polytropic, calculate power output, rate of heat transfer and rate of change in entropy (specific heat at constant pressure of air = 1.0035 kJ/kg-K, and Gas Constant of air = 0.287 kJ/kg-K).

18. An ideal, air standard regenerative Brayton cycle is working between minimum and maximum temperatures of 300 K and 1200 K respectively.

    (a) Find out the value of critical pressure ratio where the degree of regeneration becomes zero.

    (b) Calculate the efficiency of the cycle when the operating pressure ratio is 60% of the critical pressure ratio.

19. A centrifugal pump has an efficiency of 80%. The specifications of the pump are: discharge = 70m^3/hr, Head = 7m, speed = 1450 rpm and diameter = 200mm. If the speed of this pump is increased to 1750 rpm, calculate the discharge, heat developed and power input required without loss in efficiency.

20. The Willan's line measured for a four-stroke, four-cylinder is expressed as:

    FC = 0.15 + 0.03 $\times$ B.P., where FC is the rate of fuel consumption in gm/s and B.P. is the brake power in kW. The bore of each cylinder is 75 mm and stroke is 90 mm and the speed is 3000 rpm.

    Calculate indicated power, mechanical efficiency and indicated mean effective pressure, when the engine is developing a brake power of 20 kW.

21. An ice making plant using refrigerant R-12 is having an evaporator saturation temperature of –25C and the condenser saturation temperature of 35C. The vapour is leaving the compressor at 65C. Following table shows the properties of the refrigerant.

Temperature C	Pressure, kPa	Saturation Enthalpy kJ/kg	
		Liquid	Vapour
25	123.7	13.3	176.5
35	850.0	69.6	201.5
Enthalpy of superheated refrigerant at 850 kPa and 65C = 225.5 kJ/kg.			

(a) Calculate the Coefficient Of Performance (COP) of this system

(b) If the capacity of the plant is 5 kW, calculate mass flow rate of refrigerant and Power consumption.

22. A reciprocating compressor is to be designed to compress 4.5 kg/min of air from 100 kPa and 27C through an overall pressure ratio of 9. The law of compression is $pV^{1.3} = \text{constant}$. Calculate the savings in power consumption and gain in isothermal efficiency, when a two-stage compressor with complete inter-cooling is used in place of a single stage compressor. Assume equal pressure ratio in both the stages of the two stage compressor. (Gas Constant = 0.287 kJ/kg-K).

MECHANICAL ENGINEERING

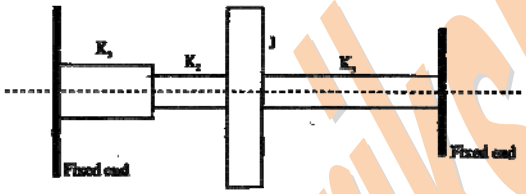
ONE MARKS QUESTIONS

1. $\underset{x\to 0}{Lt}\dfrac{\sin^2 x}{x}$ is equal to
   a. 0
   b. ∞
   c. 1
   d. -1
2. The accuracy of Simpson's rule quadrature for a step size his
   a. $O(h^2)$
   b. $O(h^3)$
   c. $O(h^4)$
   d. $O(h^5)$
3. For the matrix $\begin{bmatrix} 4 & 1 \\ 1 & 4 \end{bmatrix}$ the eigen value are
   a. 3 and -3
   b. -3 and -5
   c. 3 and 5
   d. 5 and 0
4. If x = a $(\theta+\sin\theta)$ and y = a $(1-\cos\theta)$, then $\dfrac{dy}{dx}$ will be equal to
   a. $\sin\left(\dfrac{\theta}{2}\right)$
   b. $\cos\left(\dfrac{\theta}{2}\right)$
   c. $\tan\left(\dfrac{\theta}{2}\right)$
   d. $\cot\left(\dfrac{\theta}{2}\right)$
5. The angle between two unit-magnitude coplanar vectors P(0.866, 0.500,0) and Q(0.259, 0.966,0) will be
   a. 0°
   b. 30°
   c. 45°
   d. 60°
6. The sum of the eigen values of the matrix given below is $\begin{bmatrix} 1 & 1 & 3 \\ 1 & 5 & 1 \\ 3 & 1 & 1 \end{bmatrix}$
   a. 5
   b. 7
   c. 9
   d. 18
7. The second moment of a circular area about the diameter is given by (D is the diameter).
   a. $\dfrac{\pi D^4}{4}$
   b. $\dfrac{\pi D^4}{16}$
   c. $\dfrac{\pi D^4}{32}$
   d. $\dfrac{\pi D^4}{64}$
8. A concentrated load of P acts on a simply supported beam of span L at a distance $\dfrac{L}{3}$ from the left support. The bending moment at the point of application of the load is given by
   a. $\dfrac{PL}{3}$
   b. $\dfrac{2PL}{3}$
   c. $\dfrac{PL}{9}$
   d. $\dfrac{2PL}{9}$
9. Two identical circular rods of same diameter and same length are subjected to same magnitude of axial tensile force. One of the rods is made out of mild steel having the modulus of elasticity of 206 GPa. The other rod is made out of cast iron having the modulus of elasticity of 100 GPa. Assume both the materials to be homogeneous and isotropic and the axial force causes the same amount of uniform stress in both the rods. The stresses developed are with in the proportional limit of the respective materials. Which of the following observations is correct?
   a. Both rods elongate by the same amount
   b. Mild steel rod elongates more than the cast iron
   c. Cast iron rod elongates more than the mild steel rod

d. As the stresses are equal strains are also equal in both the rods

10. The beams, one having square cross section and another circular cross-section, are subjected to the same amount of bending moment. If the cross sectional area as well as the material of both the beams are the same then
    a. maximum bending stress developed in both the beams is the same
    b. the circular beam experience more bending stress than the square one
    c. the square beam experiences more bending stress than the circular one
    d. as the material is same both beams will experience same deformation

11. Consider the arrangement shown in the figure below where J is the combined polar mass moment of inertia of the disc and the shafts. K_1, K_2, K_3 are the torsional stiffness of the respective shafts. The natural frequency of torsional oscillation of the disc is given by



    a. $\sqrt{\dfrac{K_1+K_2+K_3}{J}}$
    b. $\sqrt{\dfrac{K_1K_2+K_2K_3+K_3K_1}{J(K_1+K_2)}}$
    c. $\sqrt{\dfrac{K_1+K_2+K_3}{J(K_1K_2+K_2K_3+K_3K_1)}}$
    d. $\sqrt{\dfrac{K_1K_2+K_2K_3+K_3K_1}{J(K_2+K_3)}}$

12. Maximum shear stress developed on the surface of a solid circular shaft under pure torsion is 240 MPa. If the shaft diameter is doubled then the maximum shear stress developed corresponding to the same torque will be
    a. 120 MPa
    b. 60 MPa
    c. 30 MPa
    d. 15 MPa

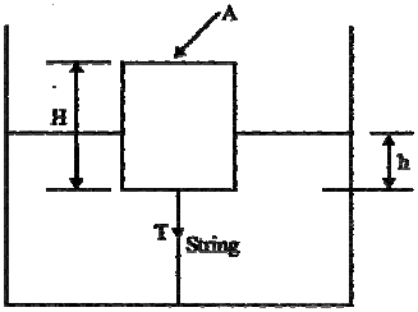
13. The mechanism used in a shaping machine is
    a. a closed 4-bar chain having 4 revolute pairs
    b. a closed 6-bar chain having 6 revolute pairs
    c. a closed 4-bar chain having 2 revolute and 2 sliding pairs
    d. an inversion of the single slider-crank chain

14. The lengths of the links of a 4-bar linkage with revolute pairs only are p, q, r and s units. Given that p< q < r < s. Which of these links should be the fixed one, for obtaining a “double crank” mechanism?
    a. links of length p
    b. links of length q
    c. link of length r
    d. link of length s

15. When a cylinder is located in a Vee-block, the number of degrees of freedom which are arrested is
    a. 2
    b. 4
    c. 7
    d. 8

16. A wire rope is designated as 6 × 19 standard hoisting. The numbers 6 × 9 represent
    a. diameter in millimeter x length in meter
    b. diameter in centimeter x length in meter
    c. number of strands x number of wires in each strand
    d. number of wires in each strand x number of strands

17. A Cylindrical body of cross-sectional area A, height H and density ρ_s, is immersed to a depth h in a liquid of density ρ, and tied to the bottom with a string. The tension in the string is



    a. ρghA
    b. $(\rho_s-\rho)ghA$
    c. $(\rho-\rho_s)ghA$
    d. $(\rho h-\rho_s H)gA$

18. A 2 kW, 40 liters water heater is switched on for 20 minutes. The heat capacity C_P, for water is 4.2 kJ/kg K. Assuming all the electrical energy has gone into heating the water, increase of the water temperature in degree centigrade is
    a. 2.7
    b. 4.0
    c. 14.3
    d. 25.25
19. A plate having 10 cm^2 areas each side is hanging in the middle of a room of 100m^2 total surface area. The plate temperature and emissivity are respectively 800 K and 0.6. The temperature and emissivity values for the surfaces of the room are 300 K and 0.3 rAcntive1v Boltzmann's constant a = 5.67×10^{-8} W/m^2K^4. The total heat loss from the tow surfaces of the plate is
    a. 13.66 W
    b. 27.32 W
    c. 27.87 W
    d. 13.66 MW
20. For a spark ignition engine, the equivalence ratio (ϕ) of mixture entering the combustion chamber has values
    a. ϕ <1 for idling and ϕ > 1 for peak power conditions
    b. ϕ >1 for both idling and peak power conditions
    c. ϕ >1 for idling and ϕ < 1 for peak power conditions
    d. ϕ <1 for both idling and peak power conditions
21. A diesel engine is usually more efficient than a spark ignition engine because
    a. diesel being a heavier hydrocarbon, releases more heat per kg than gasoline
    b. the air standard efficiency of diesel cycle is higher than the Otto cycle, at a fixed compression ratio
    c. the compression ratio of a diesel engine is higher than that of an SI engine
    d. self ignition temperature of diesel is higher than that of gasoline
22. In Rankine cycle, regeneration results in higher efficiency because
    a. pressure inside the boiler increases
    b. heat is added before steam enters the low pressure turbine
    c. average temperature of heat addition in the boiler increases
    d. total work delivered by the turbine increases
23. Considering the variation of static pressure and absolute velocity in an impulse stream turbine, across one row of moving blades
    a. both pressure and velocity decrease
    b. pressure decreases but velocity increases
    c. pressure remains constant, while velocity increases
    d. pressure remains constant, while velocity decreases
24. An industrial heat pump operates between the temperatures of 27°C and -13°C. The rates of heat addition and heat rejection are 750 Wand 1000 W, respectively. The COP for the heat pump is
    a. 7.5
    b. 6.5
    c. 4.0
    d. 3.0
25. For air with a relative humidity of 80%
    a. the dry bulb temperature is less than the wet bulb temperature
    b. the dew point temperature is less than wet bulb temperature
    c. the dew point and web bulb temperature are equal
    d. the dry bulb and dew point temperatures are equal
26. During heat treatment of steel, the hardness of various structures in increasing order is
    a. martensite, fine pearlite, coarse pearlite, spherodite
    b. fine pearlite, decreases but velocity increases
    c. martensite, coarse pearlite, fine pearlite, spherodite
    d. spherodite, coarse pearlite, fine pearlite, martensite
27. Hardness of green sand mould increases with
    a. increase in moisture content beyond 6 percent
    b. increase in permeability
    c. decrease in permeability
    d. increases in both moisture content and permeability
28. In Oxyacetylene gas welding, temperature at the inner cone of the flame is around
    a. 35000 C
    b. 3200°C

c. 2900°C
d. 2550°C

29. Cold working of steel is defined as working
a. at its reciystallisation temperature
b. above its reciystallisation temperature
c. below its recrystallisation temperature
d. at two thirds of the melting temperature of the metal

30. Quality screw threads are produced by
a. thread milling
b. thread chasing
c. thread cutting with single point tool
d. thread casting

31. As tool and work are not in contact in EDM process
a. no relative motion occurs between them
b. no water of tool occurs
c. no power is consumed during metal cutting
d. no force between tool and work occurs

32. The dimensional limits on a shaft of 25h 7 are
a. 25.000,25.021 mm
b. 25.000,24,979 mm
c. 25.000,25.007 mm
d. 25.000,24.993 mm

33. The symbol used for Transport in work study is
a. ⇒
b. T
c. ▭
d. ∇

TWO MARKS QUESTIONS

34. Consider the system of simultaneous equations
x + 2y + z = 6
2x + y + 2z =6
x + y + z = 5
This system has
a. unique solution
b. infinite number of solutions
c. no solution
d. exactly two solutions

35. The area enclosed between the parabalay = x^2 and the straight line y = x is
a. 1/8
b. 1/6
c. 1/3
d. 1/2

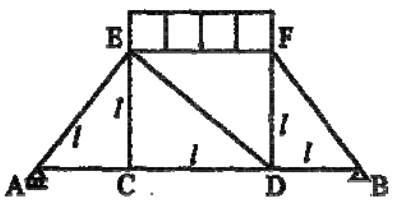
36. The solution of the differential equation $\frac{dy}{dx} + y^2 = 0$ is
a. $y = \frac{1}{x+c}$
b. $y = \frac{-x^3}{3} + c$
c. ce^x
d. unsolvable as equation is non-linear

37. The vector field is $\vec{F}\, x\hat{i} - y\hat{j}$ (where $\hat{i}$ and $\hat{j}$ are unit vector) is
a. divergence free, but not irrotational is
b. irrotational, but not divergence free
c. divergence free and irrotational
d. neither divergence free nor irrotational

38. Lapalce transform of the function sin ωt is
a. $\frac{s}{s^2+\omega^2}$
b. $\frac{\omega}{s^2+\omega^2}$
c. $\frac{s}{s^2-\omega^2}$
d. $\frac{\omega}{s^2-\omega^2}$

39. A box contains 5 black and 5 red balls. Two balls are randomly picked one after another from the box, without replacement The probability for both balls being red is
a. 1/90
b. 1/2
c. 19/90
d. 2/9

40. A truss consists of horizontal members (AC, CD, DB and EF) and vertical members (CE and DE) having length leach, The members AE, DE and BF are inclined at 45° to the horizontal. For the uniformly distributed load "p" per unit length on the members EF of the truss shown in figure given below, the force in the member CD is



a. $\frac{Pl}{2}$

b. pl

c. 0

d. $\frac{2pl}{3}$

41. A bullet of mass 'm' travels at a very high velocity v (as shown in the figure) and gets embedded inside the block of mass "M" initially at rest on a rough horizontal floor, The block with the bullet is seen to move a distance "s" along the floor. Assuming μ to be the coefficient of kinetic friction between the block and the floor and "g" the acceleration due to gravity what is the velocity v of the bullet?

a. $\frac{M+m}{m}\sqrt{2\mu gs}$

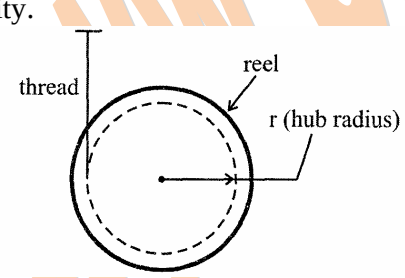
b. $\frac{M-m}{m}\sqrt{2\mu gs}$

c. $\frac{\mu(M+m)}{m}\sqrt{2gs}$

d. $\frac{M}{m}\sqrt{2\mu gs}$

Date for Q. 42-43 are given below. Solve the problems and choose correct answers.

A reel of mass "Mass" and radius of gyration "k" is rolling down smoothly from rest with one end of the thread wound on it held in the ceiling as depicated in the figure. Consider the thickness of the thread and its mass negligible in comparison with the radius 'r' of the hub and the reel mass "m". Symbol "g" represents the acceleration due to gravity.



42. The linear acceleration of the reel is

a. $\frac{gr^2}{\left(r^2+k^2\right)}$

b. $\frac{gk^2}{\left(r^2+k^2\right)}$

c. $\frac{grk}{\left(r^2+k^2\right)}$

d. $\frac{mgr^2}{\left(r^2+k^2\right)}$

43. The tension in the thread is

a. $\frac{mgr^2}{\left(r^2+k^2\right)}$

b. $\frac{mgrk}{\left(r^2+k^2\right)}$

c. $\frac{mgk^2}{\left(r^2+k^2\right)}$

d. $\frac{mg}{\left(r^2+k^2\right)}$

44. A simply supported laterally loaded beam was found to deflect more than a specified value. Which of the following measures will reduce deflection?

a. Increase the area moment of inertia
b. Increase the span of the beam
c. Select a different material having lesser modulus of elasticity
d. Magnitude of the load to be increased

45. A shaft subjected to torsion experiences a pure shear stress ton the surface. The maximum principal stress on the surface which is at 45° to the axis will have a value

a. $\tau \cos 45°$
b. $2\tau \cos 45°$
c. $2\tau \cos 45°$
d. $2\tau \sin 45° \cos 45°$

Data for Q. 46 are given below. Solve the problems and choose correct answers.

The state of stress at a point "P" in a two dimensional loading is such that the Mohr's circle is point located at 175 MPa on the positive normal stress axis.

46. Determine the maximum and minimum principal stresses respectively from the Mohr's circle

a. + 175 MPa, - 175 MPa
b. + 175 MPa, +175 MPa
c. 0, - 175 MPa
d. 0, 0

47. Determine the directions of maximum and minimum principal stresses at the point "P" from the Mohr's circle

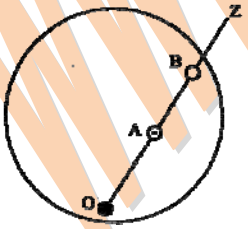
a. 0, 90°
b. 90°, 0
c. 45°, 135°
d. all directions

48. For a certain engine having an average speed of 1200 rpm, a flywheel approximated as a solid disc, is required for keeping the fluctuation of speed within 2% about the average speed. The fluctuation of kinetic energy per cycle is found to be 2kJ. What is the least possible mass of the flywheel if its diameter is not to exceed 1m?
a. 40 kg
b. 51 kg
c. 62 kg
d. 73kg

49. A flexible rotor-shaft system comprises of a 10kg rotor disc placed in the middle of a mass-less shaft of diameter 30mm and length 500 mm between bearings (shaft is being taken mass-less as the equivalent mass of the shaft is included in the rotor mass) mounted at the ends. The bearings are assumed to simulate simply supported boundary conditions. The shaft is made of steel for which the value of E is 2.1×10^{11} Pa. What is the critical speed of rotation of the shaft?
a. 60 Hz
b. 90 Hz
c. l35Hz
d. 18OHz

Data for Q. 50-51 are given below. Solve the problems and choose correct answers.

The circular disc shown in its plan view in the figure rotates in a plane parallel to the horizontal plane about the point 0 at a uniform angular velocity o. Two other points A and B are located on the line OZ at distances r and rB from 0 respectively.

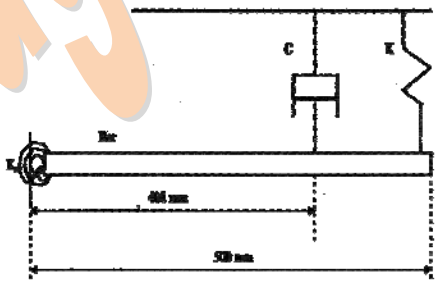


50. The velocity of point B with respect to point A is a vector of magnitude
a. 0
b. $\omega (r_B - r_A)$ and direction opposite to the direction of motion of point B
c. $\omega (r_B - r_A)$ and direction same as the direction of motion of point B.
d. $\omega (r_B - r_A)$ and direction being from 0 to Z.

51. The acceleration of point B with respect to point A is a vector of magnitude
a. 0
b. $\omega (r_B - r_A)$ and direction same as the direction of motion of point B.
c. $\omega (r_B - r_A)$ and direction opposite to be direction of motion of point B.
d. $\omega (r_B - r_A)$ and direction being from Z to 0,

Date for Q. 52-53 are given below. Solve the problems and choose correct answers.

A uniform rigid slender bar of mass 10kg, hinged at the left end is suspended with the help of spring and damper arrangement as shown in the figure where K2kN/m, C500 Ns/m and the stiffness of the torsional spring K_0 is 1 kN/m/rad. Ignore the hinge dimensions.



52. The un-damped natural frequency of oscillations of the bar about the hinge point is
a. 42.43 rad/s
b. 30 rad/s
c. 17.32 rad/s
d. 14.14 rad/s

53. The damping coefficient in the vibration equation is given by
a. 500 Nms/rad
b. 500 N/(m/s)
c. 80 Nms/rad
d. 80 N/(m/s)

54. Square key of side “d/4” each and length! is used to transmit torque “T” from the shaft of diameter “d” to the hub of a pulley. Assuming the length of the key to be equal to the thickness of the pulley, the

average shear stress developed in the key is given by

a. $\frac{4T}{ld}$

b. $\frac{16T}{ld^2}$

c. $\frac{8T}{ld^2}$

d. $\frac{16T}{\pi d^3}$

55. In a band brake the ratio of tight side band tension to the tension on the slack side is 3. if the angle of overlap of band on the drum is 1800 the coefficient of friction required between drum and the bank is

a. 0.20
b. 0.25
c. 0.30
d. 0.35

Data for Q. 56-57 are given below. Solve the problems and choose correct answers.

The overall gear ratio in a 2 stage speed reduction gear box (with all spur gears) is 12. The input and output shafts of the gear box are collinear. The countershaft which is parallel to the input and output shafts has a gear (Z_2 teeth) and pinion (Z_3 = 15 teeth) to mesh with pinion (Z_1 = 16 teeth) on the input shaft and gear (Z_4 teeth) on the output shaft respectively. It was decided to use a gear ratio of 4 with 3 module in the first stage and 4 module in the second stage.

56. Z_2 and Z_4 are

a. 64 and 45
b. 45 and 64
c. 48 and 60
d. 60 and 48

57. The centre distance in the second stage is

a. 90 mm
b. 120 mm
c. 160 mm
d. 240 mm

58. A water container is kept on a weighing balance. Water from a tap is falling vertically into the container with a volume flow rate of Q; the velocity of the water when it hits the water surface is U. At a particular instant of time the total mass of the container and water is U. At a particular instant of time the total mass of the container and water is m. The force registered by the weighing balance at this instant of time as

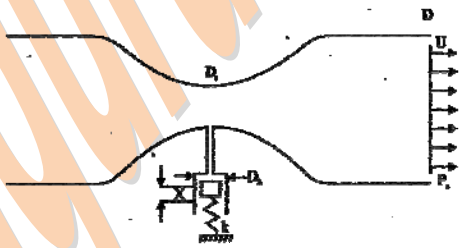
a. $mg + \rho QU$

b. $mg + 2\rho QU$

c. $mg + 2QU^2 / 2$

d. $\rho QU^2 / 2$

59. Air flows through a venturi and into atmosphere. Air density is ρ; atmospheric pressure is P_a; throat diameter is D exit diameter is D_t; and exit velocity is U. The throat is connected to a cylinder containing a ffictionless piston attached to a spring. The spring constant is k. The bottom surface of the piston is exposed to atmosphere. Due to the flow, the piston moves by distance x. Assuming incompressible frictionless flow, x is



a. $\left(\rho U^2 / 2k\right)\pi D_s^2$

b. $\left(\rho U^2 / 8k\right)\left(\frac{D^2}{D_t^2} - 1\right)\pi D_s^2$

c. $\left(\rho U^2 / 2k\right)\left(\frac{D^2}{D_t^2} - 1\right)\pi D_s^2$

d. $\left(\rho U^2 / 8k\right)\left(\frac{D^4}{D_t^4} - 1\right)\pi D_s^2$

60. A centrifugal pump running at 500 rpm and at its maximum efficiency is delivering a head of 30m at a flow rate of 60 liters per minute, If the rpm is changed to 1000, then the head H in meters and flow rate Q in liters per minute at maximum efficiency are estimated to be

a. H = 60, Q = 120
b. H = l20, Q = l20
c. H = 60, Q = 480
d. H = 120, Q = 3O

61. Match the following

P. Curtis
Q. Rateau
R. Kaplan
S. Francis

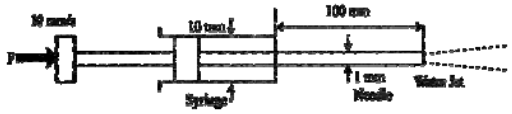
1. Reaction steam turbine
2. Gas turbine

3. Velocity compounding
4. Pressure compounding
5. Impulse water turbine
6. Axial turbine
7. Mixed flow turbine
8. Centrifugal pump

a. P-2, Q-1, R-1, S-6
b. P-3, Q-1, R-5, S-7
c. P-1, Q-3, R-1, S-5
d. P-3, Q-4, R-7, S-6

Data for Q. 62-63 are given below, Solve the problems and choose correct answers

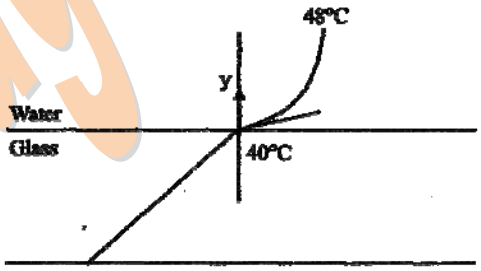
A syringe with a frictionless plunger contains water and has at its end a 100mm long needle of 1 mm diameter. The internal diameter of the syringe is 10 mm. Water density is 1000 kg/m^3. The plunger is pushed in at 10 mm/s and the water comes out as a jet



62. Assuming ideal flow, the force F in newtons required on the plunger to push out the water is
    a. 0
    b. 0.04
    c. 0.13
    d. 1.15
63. Neglect losses in the cylinder and assume fully developed laminar viscous flow throughout the needle; the Darcy friction factor is 64/Re, Where Re is the Reynolds number. Given that the viscosity of water is 1.0 × 10^{-3} kg/s m, the force F in newtons required on the plunger is
    a. 0.13
    b. 0.16
    c. 0.3
    d. 4.4
64. In a counter flow heat exchanger, for the hot fluid the heat capacity = 2 kJ/kg K, mass flow rate = 5kg/s, inlet temperature 150°C, outlet temperature = 100°C. For the cold fluid, heat capacity = 4 kJ/kg K, mass flow rate = 10 kg/s, inlet temperature = 20°C. Neglecting teat transfer to the surroundings, the outlet temperature of the cold fluid is °C is
    a. 7.5
    b. 32.5
    c. 45.5
    d. 70.0
65. Consider a laminar boundary layer over a heated flat plate. The free stream velocity is U_∞. At some distance x from the leading edge the velocity boundary layer thickness is δ_V and .the thermal boundary layer thickness is δ_T If the Prandtl number is greater than 1, then
    a. $\delta_V > \delta_T$
    b. $\delta_T > \delta_V$
    c. $\delta_V \approx \delta_T \sim (U_\infty x)^{-1/2}$
    d. $\delta_V \approx \delta_T \sim x^{-1/2}$

Data for Q. 66-67 are given below. Solve the problems and choose correct answers.

Heat is being transferred by convection from water at 48°C to a glass plate whose surface that is exposed to the water is at 40°C. The thermal conductivity of water is 0.6 W/mK and the thermal conductivity of glass is 1.2 W/mK. The spatial gradient of temperature in the water at the water-glass inerfae is dT/dy = 1 × 10^4 K/m.



66. The value of the temperature gradient in the glass at the water-glass interface in K/m is
    a. -2 × 10^4
    b. 0.0
    c. 0.5 × 10^4
    d. 2 × 10^4
67. The heat transfer coefficient h in W/m^2 K is
    a. 0.0
    b. 4.8
    c. 6
    d. 750
68. Considering the relationship TdS = dU + pdV between the entrophy (S), internal energy (U), pressure (p), temperature (T) and volume (V), which of the following statements is correct?
    a. It is applicable only for a reversible process

b. For an irreversible process, TdS > dU + pdV
c. It is valid only for an ideal gas
d. It is equivalent to 1 law, for a reversible process

69. In a gas turbine, hot combustion products with the specific heats C_P = 0.98 kJ/kg K, and C_V = 0.7538 kJ/kg K enter the turbine at 20 bar, 1500 K exit at 1 bar. The isoentropic efficiency of the turbine is 0.94. The work developed by the turbine per kg of gas flow is
a. 689.64 kJ/ kg
b. 794.66 kJ/kg
c. 1009.72 kJ/kg
d. 1312.00 kJ/kg

70. An automobile engine operates at a fuel air ratio of 0.05, volumetric efficiency of 90% and indicated thermal efficiency of 30%. Given that the calorific value of the fuel is 45 MJ/kg and the density of air at intake in 1 kg/m^3, the indicated mean effective pressure for the engine is
a. 6.075 bar
b. 6.75 bar
c. 67.5 bar
d. 243 bar

Data for Q. 71 & 72 are given below. Solve the problems and choose correct answers.
Nitrogen gas (molecular weight 28) is enclosed in a cylinder by a piston, at the initial condition of 2 bar, 298 K and 1 m^3. In a particular process, the gas slowly expands under isothermal condition, until the volume becomes 2m^3. Heat exchange occurs with the atmosphere at 298 K during this process.

71. For an engine operating on air standard Otto cycle, the clearance volume is 10% of the swept volume. The specific heat ratio of air is 1.4. The air standard cycle efficiency is
a. 3 8.3%
b. 39.8%
c. 60.2%
d. 61.7%

72. The work interaction for the Nitrogen gas is
a. 200kJ
b. 138.6kJ
c. 2kJ
d. -200kJ

73. The entrophy changes for the Universe during the process in kJ/K is
a. 0.4652
b. 0.0067
c. 0
d. -0.6711

Data for Q. 74 & 75 are given below. Solve the problems and choose correct answers.
A refrigerator based on ideal vapour compression cycle operates between the temperature limits of -20°C and 40°C. The refrigerant enters the condenser as saturated vapour and leaves as saturated liquid. The enthalpy and entropy values for saturated liquid and vapour at these temperatures are given in the table below.

T (°C)	h_1 (kJ/kg)	h_2 (kJ/kg)	S_1 (kJ/kg K)	S_2 (kJ/kg K)
–20	20	180	0.07	0.7366
40	80	200	0.3	0.67

74. If refrigerant circulation rate is 0.02 5 kg/s. the refrigeration effect is equal to
a. 2.l kW
b. 2.5 kW
c. 3.0 kW
d. 4.0 kW

75. The COP of the refrigerator is
a. 2.0
b. 2.33
c. 5.0
d. 6.0

76. Hardness of steel greatly improves with
a. annealing
b. cyaniding
c. normalizing
d. tempering

77. With a solidification factor of 0.97 × 10^6 s/m^2, the solidification time (in seconds) for a spherical casting of 200 mm diameter is
a. 539
b. 1078
c. 4311
d. 3233

78. A shell of 100mm diameter and 100mm height with the corner radius of 0.4 mm is to be produced by cup drawing. The required blank diameter is
a. ll8 mm
b. l6l mm
c. 224 mm

d. 312 mm

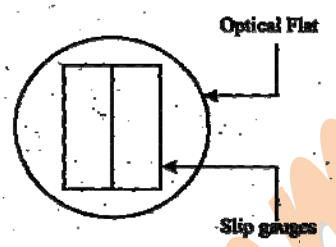
79. A brass billet is to be extruded from its initial diameter of 100mm to a final diameter of 50 mm. The working temperature of 700°C and the extrusion constant is 250 MPa. The force required for extrusion is
   a. 5.44 MN
   b. 2.72 MN
   c. 1.36 MN
   d. 0.36 MN

80. A metal disc of 20 mm diameter is to be punched from a sheet of 2 mm thickness. The punch and the dia clearance is 3%. The required punch diameter is
   a. 19.88 mm
   b. 19.84 mm
   c. 20.06 mm
   d. 20.l2 mm

81. A batch of 10 cutting tools could produce 500 components while working at 50rpm with a tool feed of 0.25 mm/rev and depth of cut of 1mm. A similar batch of 10 tools of the same specification could produce 122 components while working at 80 rpm with a feed of 0.25 mm/rev and 1 mm depth of cut. How many components can be produced with one cutting tool at 60rpm?
   a. 29
   b. 31
   c. 37
   d. 42

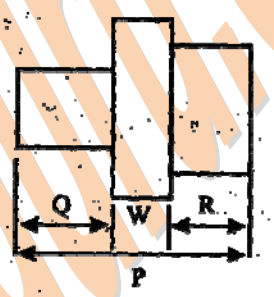
82. A threaded nut of M 16, ISO metric type, having 2 mm pitch with a pitch diameter of 14.701 mm is to be checked for its pitch diameter using two or three number of balls or rollers of the following sizes
   a. Rollers of 2mm φ
   b. Rollers of 1.155 mm φ
   c. Balls of 2 mm φ
   d. Balls of l.155mm φ

83. Two slip gauges of 10mm width measuring 1.000mm and 1.002mm are kept side by side in contact with each other lengthwise. An optical flat is kept resting on the slip gauges as shown in the figure. Monochromatic light of wavelength 0.005 8928 mm is used in the inspection. The total number of straight fringes that can be observed on both slip gauges is



   a. 2
   b. 6
   c. 8
   d. 13

84. A part shown in the figure is machined to the sizes given below
P = 35.00 ± 0.O8mm; Q = 12.00 ± 0.02mm and $R = 13.00^{+0.04}_{-0.02}\ mm$



With 100% confidence, the resultant dimension W will have the specification
   a. 9.99 ± 0.03mm
   b. 9.99 ± 0.l4mm
   c. 10.00 ± 0. 03mm
   d. 10.00 ± 0.l3mm

85. Match the following

Work material

P. Aiumhhm
Q. Die steel
R. Copper Wire
S. Titanium sheet

Type of joining

1. Submerged Arc Welding
2. Soldering
3. Thermit Welding
4. Atomic Hydrogen Welding
5. Gas Tungsten Arc Welding
6. Laser Beam Welding

   a. P-2, Q-5, R-1, S-3
   b. P-6, Q-3, R-4, S-4
   c. P-4, Q-1, R-6, S-2
   d. P-5, Q-4, R-2, S-6

Data for Q. 86-87 are given below. Solve the problems and choose correct answers.

A cylinder is turned on a lathe with orthogonal machining principle. Spindle rotates at 200 rpm. The axial feed rate is 0.25 mm per revolution.

Depth of cut is 0.4 mm. The rake angle is 10°. In the analysis it is found that the shear angle is 27.75°.

86. The thickness of the produced chip is
   a. 0.511 mm
   b. 0.528 mm
   c. 0.818mm
   d. 0.846mm

87. In the above problem, the coefficient of friction at the chip total interface obtained using Earnest and Merchant theory is
   a. 0.18
   b. 0.36
   c. 0.71
   d. 0.98

88. Two machines of the same production rate are available for use. On machine 1, the fixed cost is Rs. 100 and the variable cost is Rs. 2 per piece produced. The corresponding numbers for the machine 2 are Rs. 200 and Re. 1 respectively. For certain strategic reasons both the machines are to be used concurrently. The sale price of the first 800 units is Rs. 3.50 per unit and subsequently it is only Rs. 3.00. The breakeven production rate for each machine is
   a. 75
   b. 100
   c. 150
   d. 600

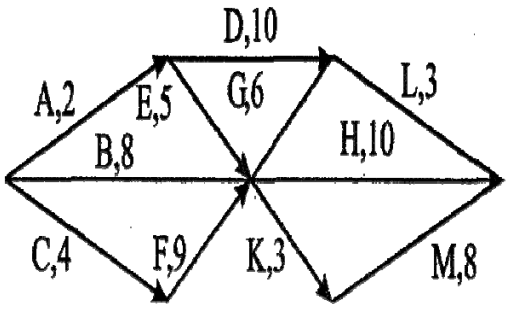
89. A residential school stipulates the study hours as 8.00 pm to 10.30 pm. Warden makes random checks on a certain student 11 occasions a day during the study hours over a period of 10 days and observes that he is studying on 71 occasions. Using 95% confidence interval, the estimated minimum hourse of his study during that 10 day period is
   a. 8.5 hours
   b. 13.9 hours
   c. 16.1 hours
   d. 18.4 hours

90. The sales of cycles in a shop in four consecutive months are given as 70, 68, 82, 95. Exponentially smoothing average method with a smoothing factor of 0.4 is used in forecasting. The expected number of sales in the next month is
   a. 59
   b. 72
   c. 86
   d. 136

91. Market demand for springs is 8,00,000 per annum. A company purchases this spring in lots and sells them. The cost of making a purchase order is Rs. 1,200. The cost of storage of springs is Rs. 120 per stored piece per annum. The economic order quantity is
   a. 400
   b. 2,828
   c. 4,000
   d. 8,000

92. A manufacturer produces two types of products, 1 and 2, at production levels of x_1 and x_2 respectively. The profit is given is $2x_1 + 5x_2$. The production constraints are:
   $x_1 + 3x_2 \leq 40$
   $3x_1 + x_2 \leq 24$
   $x_1 + x_2 \leq 10$
   $x_1 > 0, x_2 > 0$
   The maximum profit which can meet the constraints is
   a. 29
   b. 38
   c. 44
   d. 75

93. A Project consists of activities A to M shown in the net in the following figure with the durition of the activities marked in days



The project can be completed
   a. between 18, 19 days
   b. between 20,22 days
   c. between 24,26 days
   d. between 60,70 days

MECHANICAL ENGINEERING

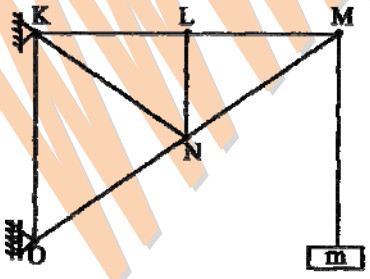
ONE MARKS QUESTIONS

1. If x = a $(\theta + \sin\theta)$ and y = a $(1 - \cos\theta)$, then $\frac{dy}{dx}$ will be equal to
   a. $\sin\left(\frac{\theta}{2}\right)$
   b. $\cos\left(\frac{\theta}{2}\right)$
   c. $\tan\left(\frac{\theta}{2}\right)$
   d. $\cot\left(\frac{\theta}{2}\right)$

2. The angle between two unit-magnitude coplanar vectors P(0.866, 0.500,0) and Q(0.259, 0.966,0) will be
   a. 0°
   b. 30°
   c. 45°
   d. 60°

3. The sum of the eigen values of the matrix given below is $\begin{bmatrix} 1 & 1 & 3 \\ 1 & 5 & 1 \\ 3 & 1 & 1 \end{bmatrix}$
   a. 5
   b. 7
   c. 9
   d. 18

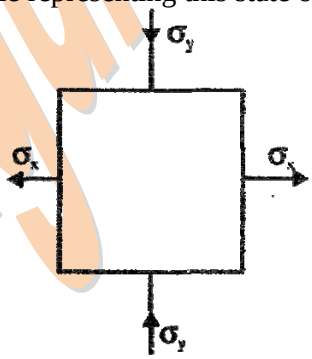
4. The figure shows a pin-jointed plane truss loaded at the point M by hanging a mass of 100 kg. The member LN of the truss is subjected to a load of member LN of the truss is subjected to a load of



   a. 0 Newton
   b. 490 Newtons in compression
   c. 981 Newtons in compression
   d. 981 Newtons in tension

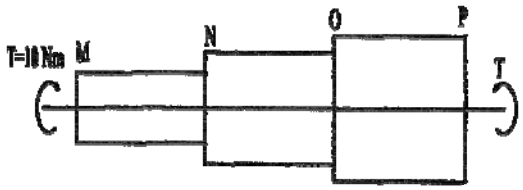
5. In terms of Poisson's ratio (v) the ratio of Young's Modulus (E) to Shear Modulus (G) of elastic materials is
   a. 2(1 + v)
   b. 2(1 - v)
   c. $\frac{1}{2}(1+v)$
   d. $\frac{1}{2}(1-v)$

6. The figure shows the state of stress at a certain point in a stressed body. The magnitudes of normal stresses in the x and y directions are 100 MPa and 20 MPa respectively. The radius of Mohr's stress circle representing this state of stress is



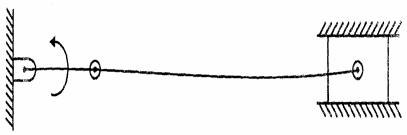
   a. 120
   b. 80
   c. 40
   d. 60

7. A torque of 10 Nm is transmitted through a stepped shall as shown in figure. The torsional stiff nesses of individual sections of lengths MN, NO and OP are 20 Nm/rad, 30 Nm/rad & 60 Nm/md respectively. The angular deflection between the ends M and P of the shaft is



   a. 0.5 rad
   b. 1.0
   c. 5.0 rad
   d. 10.0 rad

8. For a mechanism shown below, the mechanical advantage for the given configuration is



a. 0
b. 0.5
c. 1.0
d. ∞

9. A vibrating machine is isolated from the floor using springs. If the ratio of excitation frequency of vibration of machine to the natural frequency of the isolation system is equal to 0,5, the transmissibility of ratio of isolation is

a. $\frac{1}{2}$
b. $\frac{3}{4}$
c. $\frac{4}{3}$
d. 2

10. Two mating spur gears have 40 and 120 teeth respectively. The pinion rotates at 1200 rpm and transmits a torque of 20 N, m. The torque transmitted by gear is

a. 6.6 Nm
b. 20 Nm
c. 40 Nm
d. 60 Nm

11. In terms of theoretical stress concentration factor (K_t) and fatigue stress concentration factor (K_f), the notch sensitivity 'q' is expressed as

a. $\frac{(k_f - 1)}{(k_t - 1)}$
b. $\frac{(k_f - 1)}{(k_t + 1)}$
c. $\frac{(k_t - 1)}{(k_f - 1)}$
d. $\frac{(k_f + 1)}{(k_f + 1)}$

12. The S-N curve for steel becomes asymptotic nearly at

a. 10^3 cycles
b. 10^4 cycles
c. 10^6 cycles
d. 10^9 cycles

13. An incompressible fluid (kinematics viscosity, 7.4×10^{-7} m^2/s, specific gravity, 0.88) is held between two parallel plates. if the top plate is moved with a velocity of 0.5 m/s while the bottom one is held stationary, the fluid attains a linear velocity profile in the gap of 0.5 mm between these plates; the shear stress in Pascals on the surface of top plate is

a. $0.65l \times 10^{-3}$
b. 0.651
c. 6,51
d. 0.651×10^3

14. A fluid flow is represented by the velocity field $\vec{V} = ax\,\vec{i} + ay\,\vec{j}$, where a constant is. The equation of stream line passing through a point (1,2) is

a. x - 2y = 0
b. 2x + y = 0
c. 2x – y = 0
d. x + 2y = 0

15. One dimensional unsteady state heat transfer equation for a sphere with heat generation at the rate of 'q' can be written

a. $\frac{1}{r}\frac{\partial}{\partial r}\left(r\frac{\partial T}{\partial r}\right) + \frac{q}{k} = \frac{1}{\alpha}\frac{\partial T}{\partial t}$
b. $\frac{1}{r^2}\frac{\partial}{\partial r}\left(r^2\frac{\partial T}{\partial r}\right) + \frac{q}{k} = \frac{1}{\alpha}\frac{\partial T}{\partial t}$
c. $\frac{\partial^2 T}{\partial r^2} + \frac{q}{k} = \frac{1}{\alpha}\frac{\partial T}{\partial t}$
d. $\frac{\partial^2}{\partial r^2}(rT) + \frac{q}{k} = \frac{1}{\alpha}\frac{\partial T}{\partial t}$

16. A gas contained in a cylinder is compressed, the work required for compression being 5000 kJ. During the process, heat interaction of 2000 kJ causes the surroundings to the heated. The changes in internal energy of the gas during the process is

a. -7000 kJ
b. -3000 kJ
c. +3000kJ
d. +7000 kJ

17. The compression ratio of a gas power plant cycle corresponding to maximum work output for the given temperature limits of T_{min} and T_{max} will be

a. $\left(\frac{T_{max}}{T_{min}}\right)^{\frac{\gamma}{2(\gamma-1)}}$
b. $\left(\frac{T_{min}}{T_{max}}\right)^{\frac{\gamma}{2(\gamma-1)}}$
c. $\left(\frac{T_{max}}{T_{min}}\right)^{\frac{\gamma-1}{\gamma}}$

d. $\left(\frac{T_{min}}{T_{max}}\right)^{\frac{\gamma-1}{\gamma}}$

18. In the window air conditioner, the expansion device used is
    a. capillary tube
    b. thermostatic expansion valve
    c. automatic expansion value
    d. float valve
19. During the chemical dehumidification process of air
    a. dry bulb temperature and specific humidity decrease
    b. dry bulb temperature increases and specific humidity decreases
    c. dry bulb temperature decreases and specific humidity increases
    d. dry bulb temperature and specific humidity increases
20. Environment friendly refrigerant R134 is used in the new generation domestic refrigerators. Its chemical formula is
    a. CH CI F_2
    b. C_2 Cl_3 F_3
    c. C_2 Cl_2 F_4
    d. C_2 H_2 F_4
21. At the time of starting, idling and low speed operation, the carburetor supplies a mixture which can be termed as
    a. Lean
    b. slightly leaner than stoichiometric
    c. stoichiomeiric
    d. rich
22. In an interchangeable assembly, shafts of size $25.000^{+0.040}_{-0.0100}$ mm mate with holes of size $25.000^{+0.020}_{-0.000}$ mm. The maximum possible clearance in the assembly will be
    a. 10 microns
    b. 20 microns
    c. 30 microns
    d. 60 microns
23. During the execution of a CNC part program block
    NO20 GO2 X45.0 Y25.0 R5.0
    the type of tool motion will be
    a. circular Interpolation — clockwise
    b. circular Interpolation — counterclockwise
    c. linear Interpolation
    d. rapid feed
24. The mechanism of material removal in EDM process is
    a. Melting and Evaporation
    b. Melting and Corrosion
    c. Erosion and Cavitations
    d. Cavitations and evaporation
25. Two 1 mm thick steel sheets are to be spot welded at a current of 5000 A. Assuming effective resistance to be 200 micro-ohms and current flow time of 0,2 second, heat generated during the process will be
    a. 0.2 Joule
    b. 1 Joule
    c. 5 Joule
    d. 1000 Joules
26. Misrun is a casting defect which occurs due to
    a. very high pouring temperature of the metal
    b. insufficient fluidity of the molten metal
    c. absorption of gases by the liquid metal
    d. improper alignment of the mould flasks
27. The percentage of carbon in gray cast iron is in the range of
    a. 0.25 to 0.75 percent
    b. 1.25 to 1.75 percent
    c. 3 to 4 percent
    d. 8 to 10 percent
28. In PERT analysis a critical activity has
    a. maximum Float
    b. zero Float
    c. Maximum Cost
    d. minimum Cost
29. For a product, the forecast and the actual sales for December 2002 were 25 and 20 respectively. If the exponential smoothing constant (α) is taken as 0.2, the forecast sales for January2003 would be
    a. 21
    b. 23
    c. 24
    d. 27
30. There are two products P and Q with the following characteristics

Product	Demand (Units)	Order Cost (Rs./order)	Holding Cost (Rs./unit/year)
P	100	50	4
Q	400	50	1

The economic order quantity (EOQ) of products P and Q will be in the ratio
    a. 1:1
    b. 1:2
    c. l:4
    d. 1:8

TWO MARKS QUESTIONS

31. From a pack of regular from playing cards, two cards are drawn at random. What is the probability that both cards will be Kings, if first card in NOT replaced?
    a. 1/26
    b. 1/52
    c. 1/169
    d. 1/221

32. A delayed unit step function is defined as $u(t-a)=\begin{cases}0, \text{ for } t<a\\ 1, \text{ for } t\geq a\end{cases}$. Its Laplace transform is
    a. $a.e^{-as}$
    b. $\frac{e^{-as}}{s}$
    c. $\frac{e^{as}}{s}$
    d. $\frac{e^{as}}{a}$

33. The values of a function f(x) are tabulated below

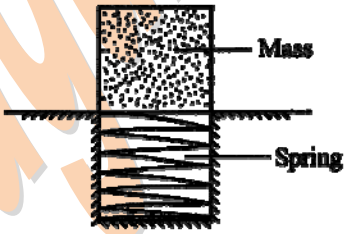
x	f(x)
0	1
1	2
2	1
3	10

    Using Newton's forward difference formula, the cubic polynomial that can be fitted to the above data, is
    a. $2x^3 + 7x^2 - 6x + 2$
    b. $2x^3 - 7x^2 + 6x - 2$
    c. $x^3 - 7x^2 - 6x^2 + 1$
    d. $2x^3 - 7x^2 + 6x + 1$

34. The volume of an object expressed in spherical co-ordinates is given by
    $V=\int_0^{2\pi}\int_0^{\pi/3}\int_0^{1} r^2 \sin\phi\, dr\, d\phi\, d\theta$
    The value of the intergal is
    a. $\frac{\pi}{3}$
    b. $\frac{\pi}{6}$
    c. $\frac{2\pi}{3}$
    d. $\frac{\pi}{4}$

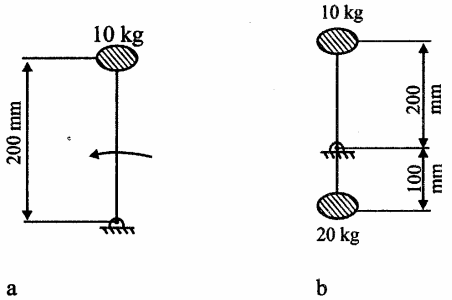
35. For which value of x will the matrix given below become singular?
$$\begin{bmatrix}8 & x & 0\\ 4 & 0 & 2\\ 12 & 6 & 0\end{bmatrix}$$
    a. 4
    b. 6
    c. 8
    d. 12

36. An ejector mechanism consists of a helical compression spring having a spring constant of K= 981 ×l0^3 N/m. It is pre-compressed by 100mm from its free state. If it is used to eject a mass of 100 kg held on it, the mass will move up through a distance of



    a. 100 mm
    b. 500 mm
    c. 58l mm
    d. l000 mm

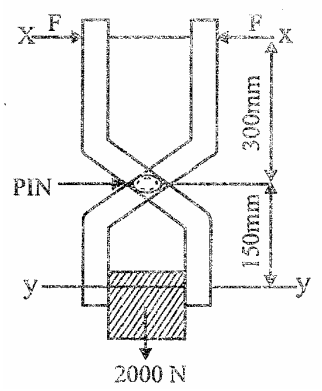
37. A rigid body shown in the fig. (a) has a mass of 10kg. It rotates with a uniform angular velocity 'ω'. A balancing mass of 20 kg is attached as shown in fig. (b). The percentage increase in mass moment of inertia as a result of this addition is



a b

    a. 25%
    b. 50%
    c. 100%
    d. 200%

38. The figure shows a pair of pin-jointed gripper-tongs holding an object weighting 2000 N. The co-efficient of friction (μ) at the gripping surface is 0.1 XX is the line of action of the input force and YY is the line of application of gripping force. If the pin-joint is assumed to be frictionless, the magnitude of force F required to hold the weight is



a. 1000N
b. 2000N
c. 2500N
d. 5000N

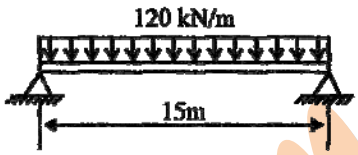
39. The figure below shows a steel rod of 25mm^2 cross sectional area. It is loaded at four points, K, L, M and N. Assume E = 200 GPa. The total change in length of the rod due to loading is

a. 1 μm
b. - l0μm
c. l6 μm
d. – 20 μm

40. A solid circular shaft of 60 mm diameter transmits a torque of 1600 N. m. The value of maximum shear stress developed is
a. 37.72 MPa
b. 47.72 MPa
c. 57.72 MPa
d. 67.72 MPa

Data for Q. 41 & 42 are given below. Solve the problems and choose correct answers.

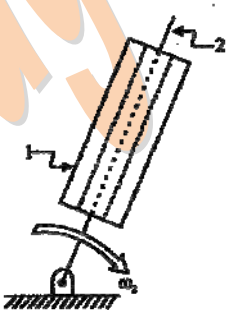
A steel beam of breadth 120 mm and height 750mm is loaded as shown in the figure. Assume E_{steel} = 200 GPa,



41. The beam is subjected to a maximum bending moment of
a. 3375 kNm
b. 4750 kNm
c. 6750 kNm
d. 8750 kNm

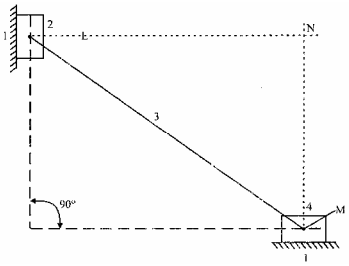
42. The value of maximum deflection of the beam is
a. 93.75mm
b. 83.75mm
c. 73.75rnm
d. 63.75mm

43. In the figure shown, the relative velocity of link 1 with respect of link 2 is 12 m/sec. Link 2 rotates at a constant speed of 120 rpm. The magnitude of Coriolis component of acceleration of link 1 is



a. 302 m/s^2
b. 604 m/s^2
c. 906 m/s^2
d. 1208 m/s^2

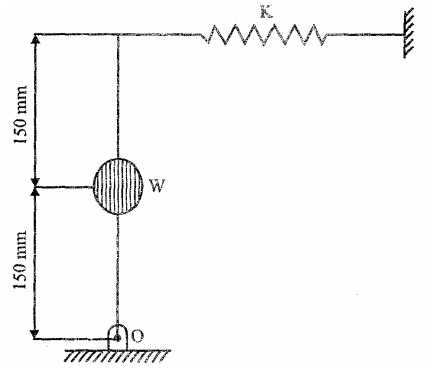
44. The figure below shows a planar mechanism with single degree of freedom. The instant center 24 for the given configuration in located at a position



a. L
b. M
c. N

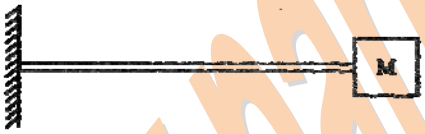
d. ∞

45. A uniform stiff rod of length 300mm and having a weight of 300 N is pivoted at one end and connected to a spring at the other end, For keeping the rod vertical in a stable position the minimum value of spring constant K needed is



a. 300 N/m
b. 400 N/m
c. 500 N/m
d. 1000 N/m

46. A mass M, of 20Kg is attached to the free end of a steel cantilever beam of length 1000mm having a cross-section of 25 × 25 mm. Assume the mass of the cantilever to be neglible and E_{steel} = 200 GPa. If the lateral vibration of this system is critically damped using a viscous damper, the damping constant of the damper is



a. 1250 Ns/m
b. 625 L/m
c. 3l2.50 Ns/m
d. 156.25 Ns/m

47. Match the following

Type of Mechanism

P. Scott - Russell mechanism
Q. Geneva mechanism
R. Off-set slider-crank mechanism
S. Scotch Yoke mechanism

Motion achieved

1. Intermittent motion
2. Quick return motion
3. Simple harmonic motion
4. Straight line motion

a. P-2 Q-3 R-1 S-4
b. P-3 Q-2 R-4 S-1
c. P-4 Q-l R-2 S-3
d. P-4 Q-3 R-l S-2

48. Match the following with respect to spatial mechanisms.

Type of Joint

P-Revolute
Q-Cylindrical
R-Spherical

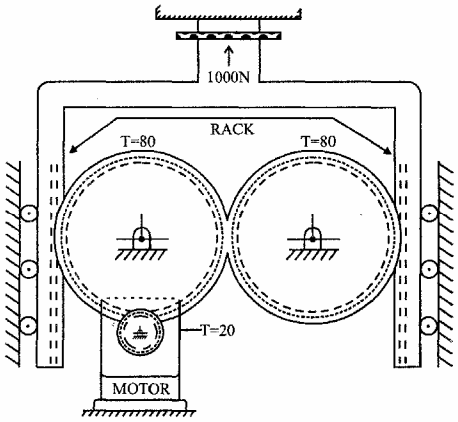
Degrees of constraint

1. Three
2. Five
3. Four
4. Two
5. Zero

a. P-1 Q-3 R-1
b. P-5 Q-4 R-3
c. P-2 Q-3 R-1
d. P-4 Q-5 R-3

Data for Q. 49-50 are given below. Solve the problems and choose correct answers.

A compacting machine shown in the figure below is used to create a desired thrust force by using a rack and pinion arrangement. The input gear in mounted on the motor shaft. The gears have in volute teeth of 2 mm module.



49. If the drive efficiency is 80%, the torque required on the input shaft to create 1000 N output thrust is

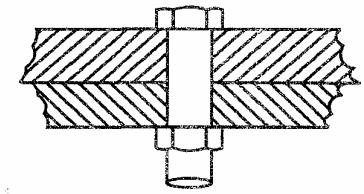
a. 20 Nm
b. 25 Nm
c. 32 Nm
d. 50 Nm

50. 19. If the pressure angle of the rack is 20°, the force acting along the line of action between the rack and the gear teeth is

a. 250 N

b. 342 N
c. 532 N
d. 600 N

51. In a bolted joint two members are connected with an axial tightening force of 2200 N. If the bolt used has metric threads of 4 mm pitch, the torque required for achieving the tightening force is



a. 0.7 Nm
b. 1.0 Nm
c. 1.4 Nm
d. 2.8 Nm

52. Match the following

Type of gears

P. Bevel gears
Q. Worm gears
R. Herringbone gears
S. Hypoid gears

Arrangement of shafts

1. Non-parallel off-set shafts
2. Non-parallel intersecting shafts
3. Non-parallel, non-intersecting shafts
4. Parallel shafts

a. P-4, Q-2, R-1, S-3
b. P-2, Q-3, R-4, S- 1
c. P-3, Q-2, R-l, S-4
d. P-l, Q-3, R-4, S-2

53. The following data about the flow of liquid was observed in a continuous chemical process plant

Flow rate	Mean value of flow rate (x)	Frequency (f)	fx
7.5 – 7.7	7.6	1	7.6
7.7 – 7.9	7.8	5	39
7.9 – 8.1	8.0	35	280
8.1 – 8.3	8.2	14	139
8.3 – 8.5	8.4	12	100.8
8.5 – 8.7	8.6	10	86

Mean flow rate of the liquid is

a. 8.00 liters/sec
b. 8.06 liters/sec
c. 8.16 liters/sec
d. 8.26 liters/sec

54. For a fluid flow through a divergent pipe of length L having inlet and outlet radii of R_1 and R_2 respectively and a constant flow rate of Q, assuming the velocity to be axial and unifonu at any cross-section, the acceleration at the exit is

a. $\frac{2Q(R_1 - R_2)}{\pi L R_2^3}$
b. $\frac{2Q^2(R_1 - R_2)}{\pi L R_2^3}$
c. $\frac{2Q^2(R_1 - R_2)}{\pi^2 L R_2^5}$
d. $\frac{2Q^2(R_2 - R_1)}{\pi^2 L R_2^5}$

55. A closed cylinder having a radius R and height H is filled with oil of density ρ. If the cylinder is rotated about its axis at an angular velocity of ω, the thrust at the bottom of the cylinder is

a. $\pi R^2 \rho g H$
b. $\pi R^2 \frac{\rho \omega^2 R^2}{4}$
c. $\pi R^2 \left(\rho \omega^2 R^2 + \rho g H\right)$
d. $\pi R^2 \left(\frac{\rho \omega^2 R^2}{4} + \rho g H\right)$

56. For air flow over a flat plate, velocity (U) and boundary layer thickness (δ) can be expressed respectively, as

$$\frac{U}{U_a} = \frac{3}{2}\frac{y}{\delta} - \frac{1}{2}\left(\frac{y}{\delta}\right)^3 ; \delta = \frac{4.64x}{\sqrt{\mathrm{Re}_x}}$$

If the free stream velocity is 2m/s, and air has kinematics viscosity of 1.5×10^{-5} m^2/s and density of 1.23 kg/m^3, the wall stree at x = 1m, is

a. 2.36×10^2 N/m^2
b. 43.6×10^{-3} N/m^2
c. 4.36×10^{-3} N/m^2
d. 2.18×10^{-3} N/m^2

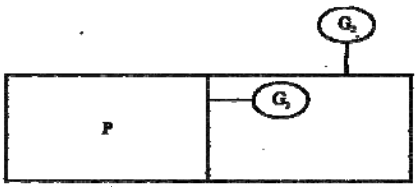
57. A centrifugal pump is required to pump water to an open water tank situated 4 km away from the location of the pump through a pipe of diameter 0.2 m having Darcy's friction factor of 0.01. the average speed of water in the pipe is 2m/s. If it is to maintain a constant head of 5-m in the tank neglecting other minor losses, the

absolute discharge pressure at the pump exit is

a. 0.449 bat
b. 5.50. bar
c. 44.911 bar
d. 55.20. bar

58. The pressure gauges G_1 and G_2 installed on the system show pressure of P_{G1} = 5.00 bar and P_{G2} = 1.00 bar. Then value of unknown pressure P is

ATMOSPHERIC PRESSURE 1.01 Bar



a. 1.01 bar
b. 2.01 bar
c. 5.00 bar
d. 7.01 bar

59. At a hydro electric power plant site, available head and flow rate are 24.5 m and 10. $1m^3/s$ respectively. If the turbine to be installed is required to run at 4.0 revolution per second (rps) with an overall efficiency of 90%, the suitable type of turbine for this site is

a. Francis
b. Kaplan
c. Pelton
d. Propeller

60. Match the following

P - Reciprocating pump
Q - Axial flow pump
R - Microhydel plant
S - Backward curved vanes

1. Plant with power output below 100 kW
2. Plant with power output between 100kW to 1MW
3. Positive displacement
4. Draft tube
5. High flow rate, low pressure ratio
6. Centrifugal pump impeller

Codes;

a. P-3, Q-5, R-6, S-2
b. P-3, Q-5, R-2, S-6
c. P-3, Q-5, R-1, S-6
d. P-4, Q-5, R-1, S-6

61. A solar collector receiving solar radiation at the rate of 0.6 kW/m^2 transforms it to the internal energy of a fluid at an overall efficiency of 50%. The fluid heated to 350 K is used to run a heat engine which rejects heat at 315 K. If the heat engine is to deliver 2.5 kW power, the minimum area of the solar collector required would be

a. 83.33 m^2
b. 16.66 m^2
c. 39.68 m^2
d. 79.36 m^2

62. A stainless steel tube (k_s = 19 W/mK) of 2 cm ID and 5 cm OD in insulated with 3 cm thick asbestos (k_a = 0.2 W/mK). If the temperature difference between the inner most and outermost surfaces is 600°c, the heat transfer rate per unit length is

a. 0.94 W/m
b. 9.44 W/m
c. 944.72 W/m
d. 9447.21 W/m

63. A spherical thermocouple junction of diameter 0.706 mm is to be used for the measurement of temperature of a gas stream. The convective heat transfer co-coefficient on bend surface is 400 W/m^2 K. Thermo physical properties of thermocouple material are k = 20 W/m^2K, C = 400 J/kg K and ρ = 8500 kg/m^3. If the thermocouple initially at 30° C is placed in a hot stream of 300°C, the time taken by the bead to reach 298°C, is

a. 2.35 s
b. 4.9 s
c. 14.7 s
d. 29.4 s

64. In a condenser, water enters at 30°C and flows at the rate 1500 kg/hr. The condensing steam is at a temperature of 120°C and cooling water leaves the condenser at 80°C. Specific heat of water is 4.187 kJ/kgK. If the overall heat transfer coefficient is 2000 W/m^2 K, the heat transfer area is

a. 0.707 m^2
b. 7.07 m^2
c. 70.7 m^2
d. 141.4 m^2

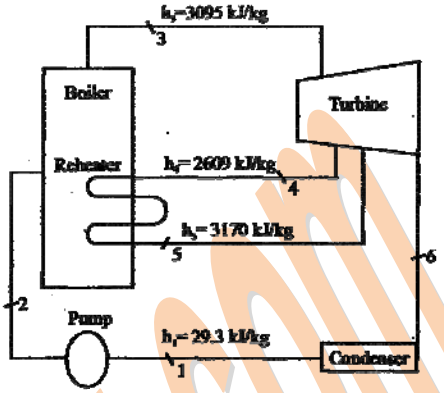
65. A steel billet of 2000 kg mass is to be cooled from 1250 K to 450 K. The heat released during this process is to be used as a source of energy. The ambient temperature is 303 K and specific heat of steel is 0.5 kJ/kg K. The available energy of this billet is
    a. 490.44 MJ
    b. 30.95 MJ
    c. 10.35 MJ
    d. 0.10 MJ

66. During a Morse test on a 4 cylinder engine, the following measurements of brake power were taken at constant speed.
    All cylinders firing- 3037 kW
    Number 1 cylinder not firing -2102 kW
    Number 2 cylinder not firing -2102 kW
    Number 3 cylinder not firing -2100 kW
    Number 4 cylinder not firing -2098kW
    The mechanical efficiency of the engine is
    a. 91.53%
    b. 8 5.07%
    c. 81.07%
    d. 61.22%

67. An engine working on air standard Otto cycle has a cylinder diameter of 10 cm and stroke length of 15 cm. The ratio of specific heats for air is 1.4. If the clearance volume is 196.3 cc and the heat supplied per kg of air per cycle is 1800 kJ/kg, the work output per cycle per kg of air is
    a. 879.1 kJ
    b. 890.2 kJ
    c. 895.3 kJ
    d. 973.5 kJ

Data for Q. 68 & 69 are given below. Solve the problem and choose the correct answers.

Consider a steam power plant using a reheat cycle as shown. Steam leaves the boiler and enters the turbine at 4 MPa, 350°C (h_3 = 3095 kJ/kg). After expansion in the turbine to 400 kPa (h_4 = 2609 kJ/kg), the steam is reheated to 350°C (h_5 = 3170 kJ/kg), and then expanded in a low pressure turbine to 10 kPa (h_6 =2165 kJ/kg) the specific volume of liquid handled by the pump can be assumed to be



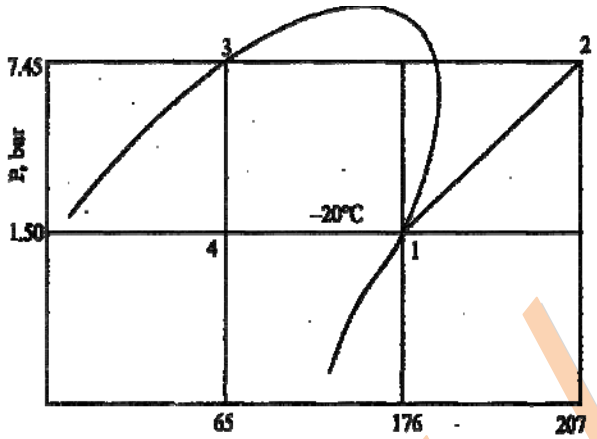
68. The thermal efficiency of the plant neglecting pump work is
    a. 15.8%
    b. 41.1%
    c. 48.5%
    d. 58.6%

69. The enthalpy at the pump discharge (h_2)is
    a. 0.33 kJ/kg
    b. 3.33 kJ/kg
    c. 4.0 kJ/kg (d)
    d. 33.3 kJ/kg

70. is used to drive a refrigerator having a coefficient of performance of 5. The energy absorbed from low temperature reservoir by the refrigerator for each U of energy absorbed from high temperature source by the engine is
    a. 0.14 kJ
    b. 0.71 kJ
    c. 3.5 kJ
    d. 7.1 kJ

71. Dew point temperature of air at one atmospheric pressure (1.013 bar) is 18°C. The air dry bulb temperature is 30°C. The saturation pressure of water at 18°C and 30°C are 0.02062 bar and 0.04241 bar respectively. The specific heat of air and water vapour respectively are 1.005 and 1.88 id/kg K and the latent heat of vaporization water of 0°C is 2500 kJ/kg. The specific humidity (kg/kg of dry air) and enthalpy (kg/kg of dry air) of this moist air respectively, are
    a. 0.0105 1, 52.64
    b. 0.01291, 63.15
    c. 0.01481, 78.60
    d. 0.01532, 81.40

72. A R-12 refrigerant reciprocating compressor operates between the condensing temperature of 30°C and evaporator temperature of -20°C. The clearance volume ratio of the compressor is 0.03. Specific heat ratio of the vapour is 1.15 and the specific volume at the suction is 0.1089 m^3/kg. Other properties at various states are given in the figure. To realize 2 tons of refrigeration, the actual volume effect of clearance is



a. 6.35×10^{-3} m^3/s
b. 63.5×10^{-3} m^3/s
c. 635×10^{-3} m^3/s
d. 4.88×10^{-3}/s

73. Go and NO-GO plug gauges are to be designed for a hole $20.000^{+0.050}_{-0.010}$ mm. Gauge tolerances can be taken as 10% of the hole tolerance, Following ISO system of gauge design, sizes of GO and NO-GO gauge will be respectively
a. 20.010 mm and 20.050mm
b. 20.0l4 mm and 20.046
c. 20.006 mm and 20.054mm
d. 20.014 mm and 20.054

74. 10mm diameter holes are to be punched in a steel sheet of 3 mm thickness. Shear strength of the material is 400 N/mm^2 and penetration is 40%. Shear provided on the punch is 2 mm. The blanking force during the operation will be
a. 22.6kN
b. 37.7kN
c. 61.6kN
d. 94.3kN

75. Through holes of 10mm diameter are to be drilled in a steel plate of2O mm thickness, Drill spindle speed is 300 rpm, feed 0.2 mm/rev and drill point angle is 120°. Assuming drill over travel of 2 mm, the time for producing a hole will be
a. 4 seconds
b. 25 seconds
c. 100 seconds
d. 110 seconds

76. In a 2-D CAD package, clockwise circular are of radius 5, specified from P_1 (15, l0) to P_2 (10, 15) will have its center at
a. (l0,l0)
b. (15,10)
c. (15,15)
d. (l0,15)

77. Gray cast iron blocks 200 × 100 × l0 mm are to be cast in sand moulds. Shrinkage allowance for pattern making is 1%. The ratio of the volume of pattern to that of the casting will be
a. 0.97
b. 0.99
c. 1.01
d. l.03

78. In an orthogonal cutting test on mild steel, the following data were obtained

Cutting speed	: 40 m/min
Depth of cut	: 0.3mm
Tool rake angle	: + 5°
Chip thickness	: 1.5mm
Cutting force	: 900 N
Thrust force	: 450 N

Using Merchant's analysis, the Friction angle during the machining will be
a. 26.6°
b. 31.5°
c. 45°
d. 63.4°

79. In a rolling process, sheet of 25 mm thickness is rolled to 20 mm thickness. Roll is of diameter 600mm and it rotates at 100prm. The roll strip contact length will be
a. 5 mm
b. 39 mm
c. 78 mm
d. 120mm

80. In a machining operation, doubling the cutting speed reduces the tool life to $\frac{1}{8}$ th

of the original value. The exponent n in Taylor's tool life equation $VT^n = C$, is

a. $\frac{1}{8}$

b. $\frac{1}{4}$

c. $\frac{1}{3}$

d. $\frac{1}{2}$

81. Match the following

Feature to be inspected

P-Pitch and Angle errors of screw thread

Q-Flatness error of a surface

R-Alignment error of a surface plate

S-Profile of a cam

Instrument

1. Auto Collimator
2. Optical Interferometer
3. Dividing Head and Dial Gauge
4. Spirit Level
5. Sine bar
6. Tool maker's Microscope

a. P-6 Q-2 R-4 S-6

b. P-5 Q-2 R-1 S-6

c. P-6 Q-4 R-1 S-3

d. P-1 Q-4 R-4 S-2

82. Match the following

Product

P-Molded luggage

Q-Packaging containers for liquid

R-Long structural shapes

S-Collapsible tubes

Process

1. Injection molding
2. Hot rolling
3. Impact extrusion
4. Transfer molding
5. Blow molding
6. Coining

a. P-1 Q-4 R-6 S-3

b. P-4 Q-5 R-2 S-3

c. P-1 Q-5 R-3 S-2

d. P-5 Q-1 R-2 S-2

83. Typical machining operations are to be performed on hard-to-machine materials by using the processes listed below. Choose the best set of Operation- Process combinations

Operation

P-Debarring (internal surface)

Q-Die sinking

R-Fine hole drifting in thin sheets

S-Tool sharpening

Process

1. Plasma Arc Machining
2. Abrasive Flow Machining
3. Electric Discharge Machining
4. Ultrasonic Machining
5. Laser beam Machining
6. Electrochemical Grinding

a. P-1 Q-5 R-3 S-4

b. P-1 Q-4 R-1 S-2

c. P-5 Q-l R-2 S-6

d. P-2 Q-3 R-5 S-6

84. From the lists given below, choose the most appropriate set of heat treatment process and the corresponding process characteristics

Process

P - Tempering.

Q - Austempering

R - Martempering

Characteristics

1. Austenite is converted into bainite
2. Austenite is converted into marten site
3. Cementite is converted into globular structure
4. Both hardness and brittleness are reduced
5. Carbon is absorbed into the metal

a. P-3 Q-1 R-5

b. P-4 Q-3 R-2

c. P-4 Q-1 R-2

d. P-1 Q-5 R-4

85. A standard machine tool and an automatic machine tool are being compared for the production of a component. Following data refers to the two machines.

	Standard Machine Tool	Automatic Machine Tool
Setup time	30 mm.	2 hours
Machining time per piece	22 mm,	5 min
Machine rate	Rs. 200 per hour	Rs. 800 per hours

The breakeven production batch size above which the automatic machine tool will be economical to use, will be

a. 4
b. 5
c. 24
d. 225

86. A soldering operation was work-sampled over two days (16 hours) during which an employee soldered 108 joints. Actual working time was 90% of the total time and the performance rating was estimated to be 120 percent. If the contract provides allowance of 20 percent of the total time available, the standard time for the operation would be

a. 8 min.
b. 8.9 min
c. l0 min
d. 12 min

87. An electronic equipment manufacturer has decided to add a component sub-assembly operation that can produce 80 units during a regular 8-hour shift. This operation consists of three activities as below

Activity	**Standard time (mm)**
M. Mechanical assembly	12
E. Electric wiring	16
T. Test	3

For line balancing the number of work stations required for the activities M, E and T would respectively be

a. 2, 3, 1
b. 3, 2, 1
c. 2, 4, 2
d. 2, 1, 3

88. A maintenance service facility has Poisson arrival rates, negative exponential service time and operates on a 'first come first served' queue discipline. Break-downs occur on an average of 3 per day with a range of zero to eight. The maintenance crew can service an average of 6 machines per day with a range of zero to seven,

The mean waiting time for an item to be serviced would be

a. 1/6 day
b. 1/3 day
c. 1 day
d. 3 day

89. A company has an annual demand of 1000 units, ordering cost of Rs.l00/ order and carrying cost of Rs. 100/unit-year. If the stock-out costs are estimated to be nearly Rs. 400 each time the company runs out-of-stock, the safety stock justified by the carrying cost will be

a. 4
b. 20
c. 40
d. 100

90. A company produces two types of toys: P and Q. Production time of Q is twice that of P and the company has a maximum of 2000 time units per day. The supply of raw material is just sufficient to produce 1500 toys (of any type) per day. Toy type Q requires an electric switch which is available @600 pieces per day only. The company makes a profit of Rs.3 and Ps. 5 on type P and Q respectively. For maximization of profits, the daily production quantities of P and Q toys should respectively be

a. 1000, 500
b. 500, 1000
c. 800, 600
d. 1000, 1000

MECHANICAL ENGINEERING

ONE MARKS QUESTIONS

1. Stokes theorem connects
   a. a line integral and a surface integral
   b. a surface integral and a volume integral
   c. a line integral and a volume integral
   d. gradient of a function and its surface integral

2. A lot has 10% defective items. Ten items are chosen randomly from this lot. The probability that exactly 2 of the chosen items are defective is
   a. 0.0036
   b. 0.1937
   c. 0.2234
   d. 0.3 874

3. $\int_{-a}^{a}\left(\sin^6 x+\sin^7 x\right)dx$ is equal to
   a. $2\int_{0}^{a}\sin^6 x\,dx$
   b. $2\int_{0}^{a}\sin^7 x\,dx$
   c. $2\int_{0}^{a}\left(\sin^6 x+\sin^7 x\right)dx$
   d. zero

4. A is a 3 × 4 real matrix and Ax = b is an inconsistent system of equations. The highest possible rank of A is
   a. 1
   b. 2
   c. 3
   d. 4

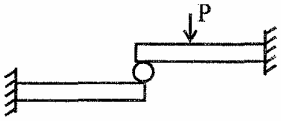
5. Changing the order of the integration in the double integral $I=\int_{0}^{8}\int_{x/4}^{2} f(x,y)\,dy\,dx$ leads to $I=\int_{r}^{8}\int_{p}^{q} f(x,y)\,dx\,dy$. What is q?
   a. 4y
   b. l6y^2
   c. x
   d. 8

6. The time variation of the position of a particle m rectilinear motion is given by x = $2t^3 + t^2 + 2t$. If v is the velocity and a the acceleration of the particle in consistent units, the motion started with
   a. v = 0, a = 0
   b. v = 0, a = 2
   c. v = 2, a = 0
   d. v = 2, a = 2

7. A simple pendulum of length of 5m, with above of mass 1 kg, is in simple harmonic motion. As it passes through its mean position, the bob has a speed of 5 m/s. The net force on the bob at the mean position is
   a. zero
   b. 2.5N
   c. 5N
   d. 25N

8. A uniform, slender cylindrical rod is made of a homogeneous and isotropic material. The rod rests on a frictionless surface. The rod is heated uniformly. If the radial and longitudinal thermal stresses are represented by σ_r and σ_z respectively, then
   a. $\sigma_r=0,\sigma_z=0$
   b. $\sigma_r\neq 0,\sigma_z=0$
   c. $\sigma_r=0,\sigma_z\neq 0$
   d. $\sigma_r\neq 0,\sigma_z\neq 0$

9. Two identical cantilever beams are supported as shown, with their free ends in contact through a rigid roller. After the load P is applied, the free ends will have



   a. equal deflections but not equal slopes
   b. equal slopes but not equal deflections
   c. equal slopes as well as equal deflections

d. neither equal slopes nor equal deflections

10. The number of degrees of freedom of a planar linkage with 8 links and 9 simple revolute joints is

a. 1

b. 2

c. 3

d. 4

11. There are four samples P, Q, Rand S with natural frequencies 64, 96, 128 and 256 Hz, respectively. They are mounted on test setups for conducting vibration experiments. if a loud pure note of frequency 144Hz is produced by some instrument, which of the samples will show the most perceptible induced vibration?

a. P

b. Q

c. R

d. S

12. Which one of the following is criterion in the design of hydrodynamic journal bearings?

a. Summerfield number

b. Rating life

c. Specific dynamic capacity

d. Rotation factor

13. The velocity components components in the x and y directions of a two dimensional potential flow are u and v, respectively. Then $\frac{\partial u}{\partial x}$, is equal to

a. $\frac{\partial v}{\partial x}$

b. $-\frac{\partial v}{\partial x}$

c. $\frac{\partial v}{\partial y}$

d. $-\frac{\partial v}{\partial y}$

14. In a case of one dimensional heat conduction in a medium with constant properties, T is the temperature at position x, at time t. Then $\frac{\partial T}{\partial t}$ is proportional to

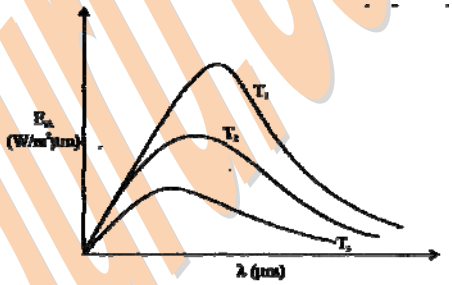
a. $\frac{T}{x}$

b. $\frac{\partial T}{\partial x}$

c. $\frac{\partial^2 T}{\partial x \partial t}$

d. $\frac{\partial^2 T}{\partial x^2}$

15. The following figure was generated from experimental data relating spectral black body emissive power to wave length at the three temperatures T_1, T_2 and T_3 ($T_1 > T_2 > T_3$).



The conclusion in that the measurements are

a. correct because the maxima in $E_{b\lambda}$ show the correct trend

b. correct because Planck's law is satisfied

c. wrong because the Stefan Boltzmann law in not satisfied

d. wrong because Wien's displacement law is not satisfied

16. The following four figures have been drawn to represent a fictitious thermodynamic cycle, on the p-v and T-s planes.

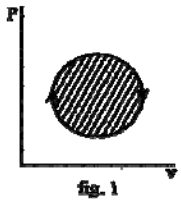


fig. 1

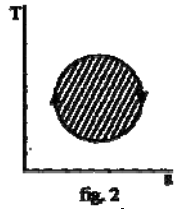


fig. 2

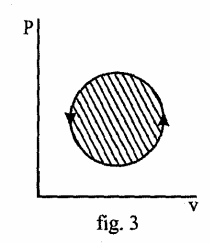


fig. 3

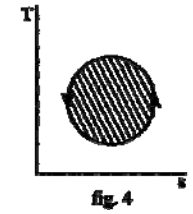
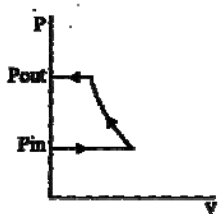


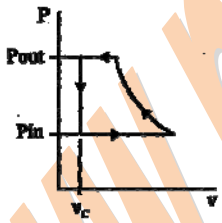
fig. 4

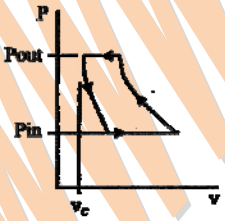
According to the first law of thermodynamics, equal areas are enclosed by

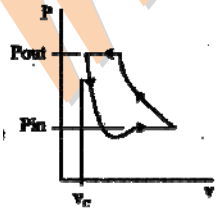
a. Figures 1 and 2
b. Figures 1 and 3
c. Figures 1 and 4
d. Figures 2 and 3

17. Ap-v diagram has been obtained from a test on a reciprocating compressor. Which of the following represents that diagram?

a.


b.


c.


d.


18. For atypical sample of ambient air (at 30°C, 75% relative humidity and standard atmospheric pressure), the amount of moisture in kg per kg of dry air will be approximately.

a. 0.002
b. 0.027
c. 0.25
d. 0.75

19. Water at 42°C is sprayed into a stream of air at atmospheric pressure, dry bulb temperature of 40°C and a wet bulb temperature of 20°C. The air leaving the spray humidifier is not saturated. Which of the following statements is true?

a. Air gets cooled and humidified
b. Air gets heated and humidified
c. Air gets heated and dehumidified
d. Air gets cooled and dehumidified

20. Match the items of List-I (Equipment) with the items of List-II (Process) the correct answer using the given codes.

Equipment

P - Hot Chamber Machine
Q - Muller
R - dielectric Baker
S - sand Blaster

Process

1. Cleaning
2. Core making
3. Die casting
4. Annealing
5. Sand mixing

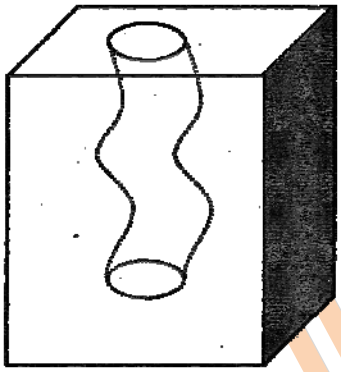
a. P-2 Q-1 R-4 S-5
b. P-4 Q-2 R-3 S-5
c. P-4 Q-5 R-1 S-2
d. P-3 Q-5 R-2 S-1

21. When the temperature of a solid metal increases,

a. strength of the metal decreases but ductility increases
b. both strength and ductility of the metal decrease
c. both strength and ductility of the metal increase
d. strength of the metal increases but ductility decreases

22. The strength of a brazed joint
    a. decreases with increases in gap between the two joining surfaces
    b. increases with increase in gap between the two joining surfaces
    c. decreases up to certain gap between the two joining surfaces beyond which it increases
    d. increases up to certain gap between the two joining surfaces beyond which it decreases

23. A zigzag cavity in a block of high strength alloy is to be finish machined. This can be carried out by using

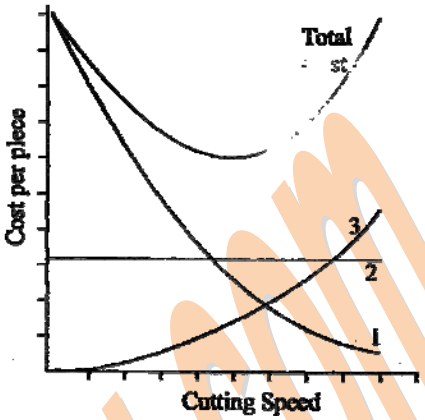


    a. electric discharge machining
    b. electro-chemical machining
    c. laser beam machining
    d. abrasive flow machining

24. In order to have interference fit, it is essential that the lower limit of the shaft should be
    a. greater than the upper limit of the hole
    b. lesser than the upper limit of the hole
    c. greater than the lower limit of the hole
    d. lesser than the lower limit of the hole

25. When 3-2-1 principle is used to support and located a three dimensional work-piece during machining, the number of degrees of freedom that are restricted is
    a. 7
    b. 8
    c. 9
    d. 10

26. The figure below shows a graph which qualitatively relates cutting speed and cost per piece produced.



The three curves 1,2 and 3 respectively represent
    a. machining cost, non-productive cost, tool changing cost
    b. non-productive cost, machining cost, tool changing cost
    c. tool changing cost, machining cost, non-productive cost
    d. tool changing cost, non-productive cost, machining cost

27. Which among the NC operations given below are continuous path operations?
    Arc Welding (AW)—Milling (M)
    Drilling (D)—Punching in Sheet Metal (P)
    Laser Cutting of Sheet (LC)— Spot Welding (SW)
    a. AW, LC and M
    b. AW, D, LC and M
    c. D, LC, P and SW
    d. D, LC, and SW

28. An assembly activity is represented on an Operation Process Chart by the symbol
    a.
    b. A
    c. D
    d. O

29. The sales of a product during the last four years were 860, 880, 870 and 890 units. The forecast for the fourth year was 876 units. If the for cast for the fifth year, using simple exponential smoothing, is equal to the forecast using a three period moving average the value of the exponential smoothing constant α is
    a. 1/7
    b. 1.5
    c. 2/7

d. 2/5

30. Consider a single server queuing model with Poisson arrivals (λ = 4/hour) and exponential service (μ. = 4/hour). The number in the system is restricted to a maximum of 10. The probability that a person who comes in leaves without joining the queue is

a. 1/11
b. 1/10
c. 1/9
d. 1/2

TWO MARKS QUESTIONS

31. Which one of the following is an eigenvector of the matrix $\begin{bmatrix} 5 & 0 & 0 & 0 \\ 0 & 5 & 5 & 0 \\ 0 & 0 & 2 & 1 \\ 0 & 0 & 3 & 1 \end{bmatrix}$

a. $\begin{bmatrix} 1 \\ -2 \\ 0 \\ 0 \end{bmatrix}$

b. $\begin{bmatrix} 0 \\ 0 \\ 1 \\ 0 \end{bmatrix}$

c. $\begin{bmatrix} 1 \\ 0 \\ 0 \\ -2 \end{bmatrix}$

d. $\begin{bmatrix} 1 \\ -1 \\ 2 \\ 1 \end{bmatrix}$

32. With a 1 unit change in b what is the change in x in the solution of the system of equations $x + y = 2, 1.01x + 0.99\ y = b$?

a. Zero
b. 2 units
c. 50 units
d. 100 units

33. By a change of variable x (u, y) = uv, y (u, v) = v/u is double integrial, the integrand f(x, y) changes to f(uv, v/u) ϕ (u,v). Then, ϕ (u, v) is

a. 2 u/v
b. 2 uv
c. v^2
d. 1

34. The right circular cone of largest volume that can be enclosed by a sphere of 1 m radius has a height of

a. 1/3m
b. 2/3m
c. $\frac{2\sqrt{2}}{3}m$
d. 4/3m

35. If $x^2\frac{dy}{dx} + 2xy = \frac{21nx}{x}$ and y(1) = 0, then what is y(e)?

a. e
b. 1
c. 1/e
d. $1/e^2$

36. The line integral $\int \vec{V}.d\vec{r}$ of the vector $\vec{V}.(\vec{r}) = 2xyz\hat{i} + x^2z\hat{j} + x^2y\hat{k}$ from the origin to the point P(1, 1,1)

a. is 1
b. is zero
c. is -1
d. cannot be determined without specifying the path

37. Starting from x_0 = 1, one step of Newton-Raphson method in solving the equation x^3 + 3x—7 = 0 gives the next value (x_1) as

a. x_1 = 0.5
b. x_1 = 1.406
c. x_1 =1.5
d. x_1 = 2

38. A single die is thrown twice. What is the probability that the sum is neither 8 nor 9?

a. 1/9
b. 5/36
c. ¼
d. ¾

Statement for Linked Answer Questions 14 & 15: The complete solution of the

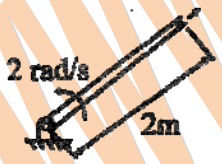
ordinary differential equation $\frac{d^2y}{dx^2}+p\frac{dy}{dx}+qy=0$ is $y=c_1e^{-x}+c_2e^{-3x}$.

39. Then, p and q are
   a. p = 3, q = 3
   b. p = 3, q = 4
   c. p = 4, q = 3
   d. p = 4, q = 4

40. Which of the following is a solution of the differential equation $\frac{d^2y}{dx^2}+p\frac{dy}{dx}+(q+1)=0$?
   a. e^{-3x}
   b. xe^{-x}
   c. xe^{-2x}
   d. x^2e^{-2x}

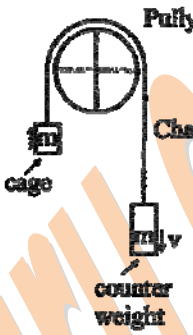
41. Two books of mass 1 kg each are kept on a table, one over the other. The coefficient of friction on every pair of contacting surfaces is 0.3, The lower book is pulled with a horizontal force F. The minimum value of F for which slip occurs between the two books is
   a. zero
   b. 1.06 N
   c. 5.74 N
   d. 8.83 N

42. A shell is fired from cannon. At the instant the shell is just about to leave the barrel, its velocity relative to the barrel is 3m/s, while the barrel is swinging upwards with a constant angular velocity of 2 rad/s. The magnitude of the absolute velocity of the shell is



   a. 3 m/s
   b. 4 m/s
   c. 5 m/s
   d. 7 m/s

43. An elevator (lift) consists of the elevator cage and a counter weight, of mass m each. The cage and the counterweight are connected by chain that passes over a pulley. The pulley is coupled to a motor. It is desired that the elevator should have a maximum stopping time of t seconds from a peak speed v, If the inertias of the pulley and the chain are neglected, the minimum power that the motor must have is



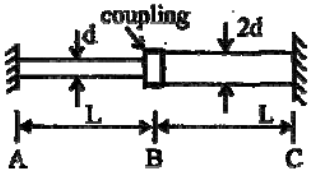
   a. $\frac{1}{2}mv^2$
   b. $\frac{mv^2}{2t}$
   c. $\frac{mv^2}{t}$
   d. $\frac{2mv^2}{t}$

44. A l kg mass of clay, moving with a velocity of 10m/s, strikes a stationary wheel and sticks to it, The solid wheel has a mass of 20kg and a radius of im. Assuming that the wheel is sei into pure rolling motion, the angular velocity of the wheel immediately after the impact is approximately

   a. zero
   b. $\frac{1}{3}rad/s$
   c. $\sqrt{\frac{10}{3}}rad/s$
   d. $\frac{10}{3}rad/s$

45. The two shafts AB and BC, of equal length and diameters d and 2d, are made of the same material. They are joined at B through a shaft coupling, while the ends A and C are built-in (cantilevered). A twisting moment T is applied to the coupling. If T_A and T_C represent the

twisting moments at the ends A and C, respectively, then



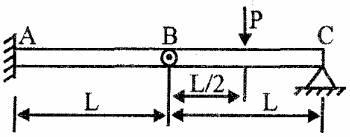
a. $T_C = T_A$

b. $T_C = 8T_A$

c. $T_C = 16T_A$

d. $T_A = l6T_C$

46. Abeam is made up of two identical bars AB and BC, by hinging them together at B. The end A is built-in (cantilevered) and the end C is simply-supported. With the load P acting as shown, the bending moment at A is



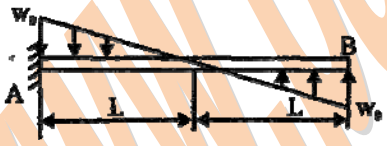
a. zero

b. $\frac{pL}{2}$

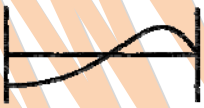
c. $\frac{3pL}{2}$

d. indeterminate

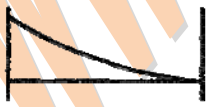
47. A cantilever beam carries the anti-symmetric load shown, where w_0 is the peak intensity of the distributed load. Qualitatively, the correct bending moment diagram for this beam is



a.

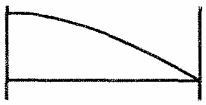


b.

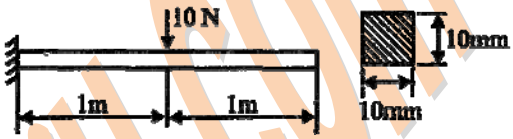


c.

d.



48. A cantilever beam has the square cross section of 10 mm × 10 mm. It carries a transverse load of 10 N. Considering only the bottom fibres of the beam, the correct representation of the longitudinal variation of the bending stress is



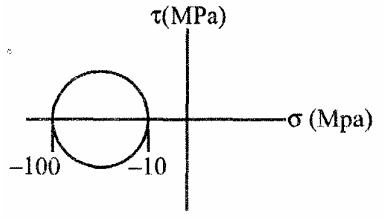
a.

b.

c.

d.

49. The Mohr's circle of plane stress for a point in a body is shown. The design is to be done on the basis of the maximum shear stress theory for yielding. Then, yielding will just begin if the designer chooses a ductile material whose yield strength is



a. 45 MPa

b. 50 MPa

c. 90 MPa

d. 100 MPa

50. A weighing machine consists of a 2 kg pan resting on a spring. In this condition, with the pan resting on the spring, the length of the spring is 200mm. When a mass of 20 kg is placed on the pan, the length of the spring becomes 100mm. For the spring, the un-deformed length l_0 and the spring constant k(spiffiness) are

a. l_0 = 220 mm, k = 1862 N/m

b. l_0 = 210 mm, k = 1960 N/m
c. l_0 = 200 mm, k = 1960 N/m
d. l_0 = 200 mm, k = 2156 N/m

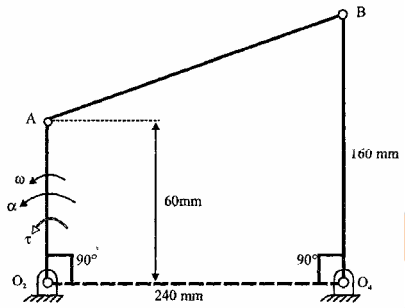
51. In a cam-follower mechanism, the follower needs to rise through 20mm during 60° of cam rotation, the first 30° with a constant acceleration and then with a deceleration of the same magnitude. The initial and final speeds of the follower are zero. The cam rotates at uniform speed of 300 rpm. The maximum speed of the follower is
a. 0.60 m/s
b. 1.20 m/s
c. 1.68 m/s
d. 2.40 m/s

52. A rotating disc of 1 m diameter has two eccentric masses of 0.5 kg each at radii of 50 mm and 60mm at angular positions of 0° and 150°, respectively. A balancing mass of 0.1 kg is to be used to balance the rotor. What is the radial position of the balancing mass?
a. 50 mm
b. 120m006Dr
c.
d. 150mm
e. 280mm

53. In a spring-mass system, the mass is 0.1 kg and the stiffness of the spring is 1 kN/m, By introducing a damper, the frequency of oscillation is found to be 90% of the original value. What is the damping coefficient of the damper'?
a. 1.2N.s/m
b. 3AN.s/m
c. 8.7N.s/m
d. 12.0N.s/m

Common Data for Questions 54, 55 and 56:

An instantaneous configuration of a four-bar mechanism, whose plane is horizontal, is shown in the figure below. At this instant, the angular velocity and angular acceleration of link Q_2A are ω = 8 rad/s and α = 0, respectively, and the driving torque (τ) is zero. The link Q_2A is balanced so that its centre of mass falls at O_2.



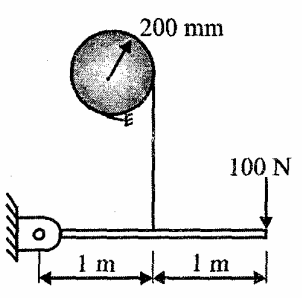
54. Which kind of 4-bar mechanism is O_2ABO_4?
a. Double crank mechanism
b. Crank-rocker mechanism
c. Double rocker mechanism
d. Parallelogram mechanism

55. At the instant considered, what is the magnitude of the angular velocity of O_4B?
a. 1 rad/s
b. 3 rad/s
c. 8 rad/s
d. 64/3 rad/s

56. At the same instant, if the component of the force is joint A and AB is 30N, then the magnitude of the joint reaction at 0_2
a. is zero
b. is 30N
c. is 78N
d. cannot be determined from the given data

Statement for linked Answer Questions 57 and 58:

A band brake consists of a lever attached to one end of the band. The other end of the band is fixed to the ground. The wheel has a radius of 200 mm and the wrap angle of the band is 270°. The braking force applied to the lever is limited to l00N, and the coefficient of friction between the band and the wheel is 0.5. No other information is given.

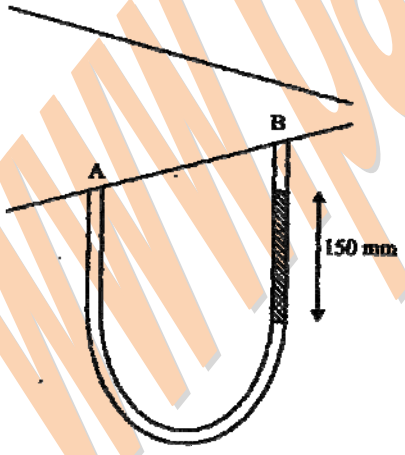


57. The maximum tension that can be generated in the band during braking is
    a. 1200N
    b. 2110N
    c. 3224N
    d. 4420N

58. The maximum wheel torque that can be completely braked is
    a. 200 N.m
    b. 382 N.m
    c. 604 N.m
    d. 844 N.m

59. A venturimeter of 20 mm throat diameter is used to measure the velocity of water in a horizontal pipe of 40 mm diameter. If the pressure difference between the pipe and throat sections is found to be 30 kPa then, neglecting frictional losses, the flow velocity is
    a. 0.2 m/s
    b. 1.0 m/s
    c. 1.4 m/s
    d. 2.0 m/s

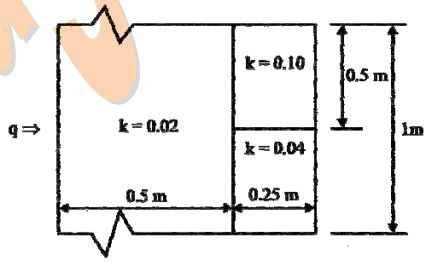
60. A U-tube manometer with a small quantity of mercury is used to the static pressure difference between two locations A and B ma conical section through which an incompressible fluid flows. At a particular flow rate, the mercury column appears as shown in the figure. The density of mercury is 13600kg/m^3 and g = 9.81 m/s^2. Which of the following is correct?



    a. Flow direction in A and B and P_A - P_B = 20 kPa
    b. Flow direction is B to A and P_A - P_B = 1.4 kPa
    c. Flow direction is A to B and P_B - P_A = 20 kPa
    d. Flow direction is B to A and P_B - P_A 1.4 kPa

61. A leaf is caught in a whirlpool. At a given instant, the leaf is at a distance of 120m from the centre of the whirlpool. The whirlpool can be described by the following velocity distribution: $V_r = -\left(\frac{60\times10^3}{2\pi r}\right)$ m/s and $V_\theta = \frac{300\times10^3}{2\pi r}$ m/s, where r (in meters in the distance from the centre of the whirlpool. What will be the distance of the leaf from the centre when it has moved through half a revolution?
    a. 48m
    b. 64m
    c. 120m
    d. 142m

62. Heat flows through a composite slab, as shown below. The depth of the slab is 1 m. The k values are in W/m.K. The overall thermal resistance in K/W is



    a. l7.2
    b. 21.9
    c. 28.6
    d. 39.2

63. A small copper ball of 5 mm diameter at 500 K is dropped into an oil bath whose temperature is 300K. The thermal conductivity of copper is 400 W/m.K, its density 9000 kg/m^3 and its specific heat 385 J/kg K. If the heat transfer coefficient is 250 W/m^2.K and lumped analysis is assumed to be valid, the rate of fall of the temperature of the ball at the beginning of cooling will be, in K/s,
    a. 8.7
    b. 13.9
    c. 17.3
    d. 27.7

64. A solid cylinder (surface 2) is located at the centre of a hollow sphere (surface 1). The diameter of the sphere is 1 m, while the cylinder has a diameter and length of 0.5m each. The radiation configuration factor F_{11} is

a. 0.375
b. 0.625
c. 0.75
d. 1

65. Hot oil is cooled from 80 to 50°C in an oil cooler which uses air as the coolant. The air temperature rises from 30 to 40°C. The designer uses a LMTD value of 26°C. The type of heat exchanger is

a. parallel flow
b. double pipe
c. counter flow
d. cross flow

Statement for linked Answer Questions 66 & 67:

An un-insulated air conditioning duct of rectangular cross section 1m × 0.5m, carrying air at 20°C with a velocity of 10 m/s, is exposed to an ambient of 30°C. Neglect the effect of duct construction material. For air in the range of 20-30°C, data are as follows: thermal conductivity = 0.025 W/m. K; viscosity = 18μPa.s; Prandtl number = 0.73; density = 1.2 kg/m^3. The laminar flow Nusselt number is 3.4 for constant wall temperature conditions and, for turbulent flow, Nu = 0.023 $Re^{0.8}$ $Pr^{0.33}$.

66. The Reynolds number for the flow is

a. 444
b. 890
c. 4.44×10^5
d. 5.33×10^5

67. The heat transfer per metre length of the duct, in watts, is

a. 3.8
b. 5.3
c. 89
d. 769

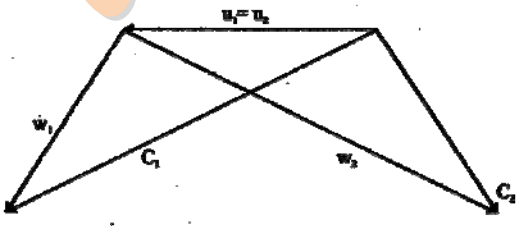
68. A reversible thermodynamic cycle containing only three processes and producing work is to be constructed. The constraints are : i) there must be one isothermal process, ii) there must be one isentropic process, iii) the maximum and minimum cycle pressures and the clearance volume are fixed, and iv) polytrophic processes are not allowed. Then the number of possible cycles are

a. 1
b. 2
c. 3
d. 4

69. Nitrogen at an initial state of 10 bar, 1 m3, and 300K is expanded isothermally to a final volume of 2 m^3. The p-v-T relation is $\left(p+\frac{q}{v^2}\right)v = RT$, where a > 0. The final pressure

a. will be slightly less than 5 bar
b. will be slightly more than 5 bar
c. will be exactly 5 bar
d. cannot be ascertained in the absence of the value of a.

70. In the velocity diagram shown below, u = balde velocity, C = absolute fluid velocity and w = relative velocity of fluid and the subscripts 1 and 2 refer to inlet and outlet. This diagram is for



a. an impulse turbine
b. a reaction turbine
c. a centrifugal compressor
d. an axial flow compressor

Common Data for Questions 71 & 72

In two air standard cycles - one operating in the Otto and the other on the Brayton cycle - air is isentropically compressed from 300 to 450K. Heat is added to raise the temperature to 600 K in the Otto cycle and to 550 K in the Brayton cycle.

71. In η_0 and η_B are the efficiencies of the Otto and Brayton cycles, then

a. $\eta_0 = 0.25, \eta_B = 0.18$
b. $\eta_0 = \eta_B = 0.33$
c. $\eta_0 = 0.5, \eta_B = 0.45$

d. it is not possible to calculate the efficiencies unless the temperature after the expansion is given

72. If W_0 and W_B are work outputs per unit mass, then

a. $W_0 > W_B$

b. $W_0 < W_B$

c. $W_0 = W_B$

d. it is not possible to calculate the work outputs unless the temperature after the expansion is given

Statement for the Linked Answer Questions 73 & 74

The following table of properties was printed out for saturated liquid and saturated vapour of ammonia. The titles for only the first two columns are available. All that we know that the other columns (columns 3 to 8) contain data on specific properties, namely, internal energy (kJ/kg), enthalpy (kJ/kg) and entropy (kJ/kg.K).

t° (C)	p (kPa)						
–20	190.2	88.76	0.3657	89.05	5.6155	1299.5	1418.0
0	429.6	179.69	0.7114	180.36	5.3309	1318.0	1442.2
20	587.5	272.89	1.0408	274.30	5.0860	1332.2	1460.2
40	1554.9	368.74	1.3574	371.43	4.8662	1341.0	1470.2

73. The specific enthalpy data are in columns

a. 3 and 7

b. 3 and 8

c. 5 and 7

d. 5 and 8

74. When saturated liquid at 40°C is throttled to -20°C, the quality at exit will be

a. 0.189

b. 0.212

c. 0.231

d. 0.788

75. Various psychrornetric processes are shown in the figure below.

Process in Figure

P. 0-1

Q. 0-2

R. 0-3

S. 0-4

T. 0-5

Name of the process

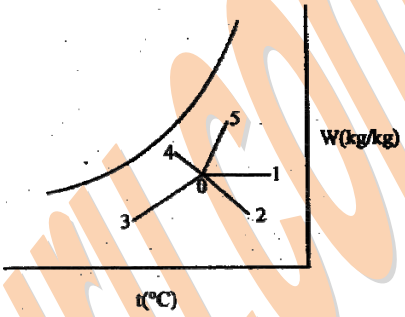
i. Chemical dehumidification

ii. Sensible heating

iii. Cooling and dehumidification

iv. Humidification with steam injection

v. Humidification with water injection



The matching pair are

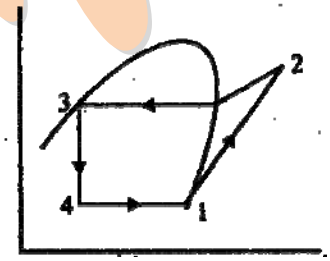
a. P-i, Q-ii, R-iii, S-iv, T-v

b. P-ii Q-i, R-iii, S-v, T-iv

c. P-ii, Q-i, R-iii, S-iv, T-v

d. P-iii, Q-iv, R-v, S-i, T-ii

76. The vapour compression refrigeration cycle is represented as shown in the figure below, with state 1 being the exit of the evaporator. The coordinate system used in this figure is



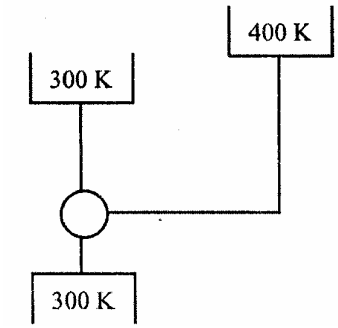
a. p-h

b. T-s

c. P-s

d. T-h

77. A vapour absorption refrigeration system is a heat pump with three thermal reservoirs as shown in the figure. A refrigeration effect of 100W is required at 250 K when the heat source available is at 400 K. Heat rejection occurs at 3 00K. The minimum value of heat required (in W) is

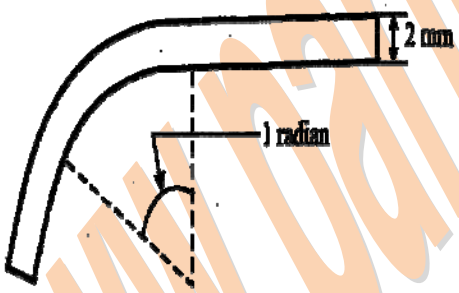


a. 167
b. 100
c. 80
d. 20

78. A mould has downsprue shose length is 20 cm and the cross sectional area at the base of the downsprue is 1 cm^2. The downsprue feeds a horizontal runner leading into the mould cavity of volume 1000 cm3. The time required to fill the mould cavity will be

a. 4.05s
b. 5.05s
c. 6.05s
d. 7.25s

79. A 2mm thick metal sheet is to be bent at an angle of one radian with a bend radius of 100 mm. If the stretch factor is 0.5, the bend allowance is



a. 99 mm
b. 100 mm
c. 101 mm
d. 102 mm

80. Spot welding of two 1 mm thick sheets of steel (density = 8000 kg/m^3) is carried out successfully by passing a certain amount of current for 0.1 second through the electrodes. The resultant weld nugget formed is 5 mm in diameter and 1.5 mm thick. If the latent heat of fusion of steel is 1400 kJ/kg and the effective resistance in the welding operation is 200 Ω), the current passing through the electrodes is approximately

a. 1480A
b. 3300A
c. 4060A
d. 9400A

81. A 600mm × 30 mm flat surface of a plate is to be finish machined on a shaper. The plate has been fixed with the 600 mm side along the tool travel direction. If the tool over-travel at each end of the plate is 20mm, average cutting speed is 8 m/mm, feed rate is 0.3 mm/ stroke and the ratio of return time to cutting time of the tool is 1: 2, the time required for machining will be

a. 8 minutes
b. 12 minutes
c. 16 minutes
d. 20 minutes

82. The tool of an NC machine has to move along a circular arc from (5, 5) to (10,10) while performing an operation. The centre of the arc is at (10, 5). Which one of the following NC tool path commands performs the above mentioned operation?

a. N0l0 G02 X10Y10 X5 Y5 R5
b. N0l0 G03 Xl0 Yl0 X5 Y5 R5
c. N0l0 GU1 X5 Y5 X10 Y10 R5
d. N010 G02 X5 Y5 X10 Y10 R5

83. Two tools P and Q have signatures 50 -5° -6° -8° -30° -0° and 5° -5° -7° -7° -8° 15° 0° (both ASA) respectively. They are used to turn components under the same machining conditions. If h_P and h_Q denote the peak-to-vellay heights of surfaces produced by the tools P and Q, the ratio h_P/h_Q will be

a. $\frac{\tan 8° + \cot 15°}{\tan 8° + \cot 30°}$
b. $\frac{\tan 15° + \cot 8°}{\tan 30° + \cot 8°}$
c. $\frac{\tan 15° + \cot 7°}{\tan 30° + \cot 7°}$
d. $\frac{\tan 7° + \cot 15°}{\tan 7° + \cot 30°}$

84. A component can be produced by any of the four processes, I, II, III and IV Process I has fixed cost of Rs. 20 and variable cost of Rs. 3 per piece. Pricess II has a fixed

cost of Rs. 50 and variable cost of Re. 1 per piece. Process III has a fixed cost of Rs. 40.00 and variable cost of Rs. 2 per piece. Process IV has fixed cost of Rs. 10 and Variable cost Rs. 4 per piece. If company wishes to produce 100 pieces of the component, from economic point of view it should choose

a. Process I
b. Process II
c. Process III
d. Process IV

85. A welding operation is time-studied during which an operator was pace-rated as 120%. The operator took, on an average, 8 minutes for producing the weld-joint. If a total of 10% allowances are allowed for this operation. The expected standard production rate of the weld-joint (in units per 8 hour day) is

a. 45
b. 50
c. 55
d. 60

86. The distribution of lead time demand for an item is as follows:

Lead time demand	Probability
80	0.20
100	0.25
120	0.30
140	0.25

The reorder level is 1.25 times the expected value of the lead time demand. The service level is

a. 25%
b. 50%
c. 75%
d. 100%

87. A project has six activities (A to F) with respective activity durations 7, 5, 6, 6, 8, 4 days. The network has three path A-B, C-D and E-F. All the activities can be crashed with the same crash cost per day. The number of activities that need to be crashed to reduce the project duration by 1 day is

a. 1
b. 2
c. 3
d. 6

88. A company has two factories S1, S2 and two warehouses Dl, D2. The supplies from S1 and S2 are 50 and 40 units respectively. Warehouse D1 requires a minimum of 20 units and a maximum of 40 units. Warehouse D2 requires a minimum of 20 units and, over and above, it can take as much as can be supplied. A balanced transportation problem is to be formulated for the above situation. The number of supply points, the number of demand points, and the total supply (or total demand) in the balanced transportation problem respectively are

a. 2, 4, 90
b. 2, 4, 110
c. 3, 4, 90
d. 3, 4, 110

Statement for lined Answer Questions 89 and 90:

Consider a linear programming problem with two variable and two constraints. The objective function is maximizing $x_1 \times x_2$. The corner points of the feasible region are (0, 0), (0, 2) (2, 0) and (4/3, 4/3)

89. If an additional constraint $x_1 + x_2 \leq 5$ is added the optimal solution is

a. (5/3, 5/3)
b. (4/3, 4/3)
c. (5/2, 5/2)
d. (5, 0)

90. Let Y_1 and Y_2 be the decision variables of the dual and v_1 and v_2 be the slack variables of the dual of the given linear programming problem. The optimum dual variables are

a. Y_1 and Y_2
b. Y_1 and v_1
c. Y_1 and v_2
d. v_1 and v_2

MECHANICAL ENGINEERING

ONE MARKS QUESTIONS

1. Match the items in columns I and II.

Column I

P. Gauss-Seidel method

Q. Forward Newton-Gauss method

R. Runge-Kutta method

S. Trapezoidal Rule

Column II

1. Interpolation
2. Non-linear differential equations
3. Numerical integration
4. Linear algebraic equations

Codes;

a. P-1, Q-4, R-3, S-2

b. P-1, Q-4, R-2, S-3

c. P-1, Q-3, R-2, S-4

d. P-4, Q-1, R-2, S-3

2. The solution of the differential equation $\frac{dy}{dx} + 2xy = e^{-x^2}$ with y(0) = 1 is

a. $(1+x)e^{+x^2}$

b. $(1+x)e^{-x^2}$

c. $(1-x)e^{+x^2}$

d. $(1-x)e^{-x^2}$

3. Let x denote a real number. Find out the INCORRECT statement.

a. S ={x : x > 3 } represents the set of all real numbers greasers than 3

b. S = {x : x^2 <0} represents the empty set.

c. S = {x : x ∈A and x ∈ B}represents the union of set A and set B.

d. S {x : a < x < b} represents the set of all real numbers between a and b, where a and b are real numbers.

4. A box contains 20 defective items and 80 non-defective items. If two items are selected at random without replacement, what will be the probability that both items are defective?

a. 1/5

b. 1/25

c. 20/99

d. 19/495

5. For a circular shaft of diameter d subjected to torque T, the maximum value of the shear stress is

a. $\frac{64T}{\pi d^3}$

b. $\frac{32T}{\pi d^3}$

c. $\frac{16T}{\pi d^3}$

d. $\frac{8T}{\pi d^3}$

6. A pin-ended column of length L, modulus of elasticity E and second moment of the cross-sectional area us loaded centrically by a compressive load P. The critical buckling load (P_{cr}) is given by

a. $P_{cr} = \frac{EI}{\pi^2 L^2}$

b. $P_{cr} = \frac{\pi^2 EI}{3L^2}$

c. $P_{cr} = \frac{\pi^2 EI}{L^2}$

d. $P_{cr} = \frac{\pi^2 EI}{L^2}$

7. For a four bar linkage in toggle position, the value of mechanical advantage is

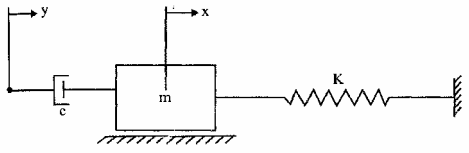
a. 0.0

b. 0.5

c. l.0

d. ∞

8. The differential equation governing the vibrating system is



a. $m\ddot{x} + c\dot{x} + k(x-y) = 0$

b. $m(\ddot{x} - \ddot{y}) + c(\dot{x} - \dot{y}) + kx = 0$

c. $m\ddot{x} + c(\dot{x} - \dot{y}) + kx = 0$

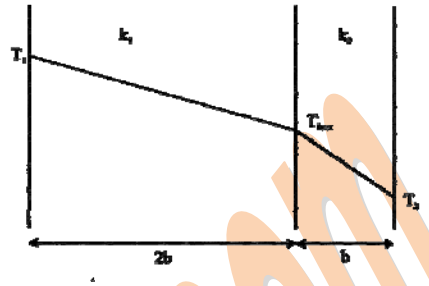
d. $m(\ddot{x} - \ddot{y}) + c(\dot{x} - \dot{y})k(x - x) = 0$

9. The number of inversions for a slider crank mechanism is
   a. 6
   b. 5
   c. 4
   d. 3
   e. shear stress is proportional to shear strain
   f. rate of shear stress is proportional to shear strain
   g. shear stress is proportional to rate of shear strain
   h. rate of shear stress is proportional to rate of shear strain

10. In a two-dimensional velocity field with velocities u and v along the x and y directions respectively, the convective acceleration along the x-direction is given by
   a. $u\frac{\partial u}{\partial x} + v\frac{\partial u}{\partial y}$
   b. $u\frac{\partial u}{\partial x} + v\frac{\partial v}{\partial y}$
   c. $u\frac{\partial u}{\partial x} + v\frac{\partial u}{\partial y}$
   d. $v\frac{\partial u}{\partial x} + u\frac{\partial u}{\partial y}$

11. In a Pelton wheel, the bucket peripheral speed is 10 m/s, the water jet velocity is 25 m/s and volumetric flow rate of the jet is $0.1 m^3/s$. If the jet deflection angle is 120°C and the flow is ideal, the power developed is
   a. 7.5 kW
   b. 15.0 kW
   c. 22.5 kW
   d. 37.5 kW

12. In a composite slab, the temperature at the interface (T_{inter}) between two materials is equal to the average of the temperature at the two ends. Assuming steady one dimensional heat conduction, which of the following statements is true about the respective thermal conductivities?



   a. $2K_1 = K_2$
   b. $k_1 = k_2$
   c. $2k_1 = 3k_2$
   d. $k_1 = 2k_2$

13. Dew point temperature is the temperature at which condensation begins when the air is cooled at constant
   a. volume
   b. entropy
   c. pressure
   d. enthalpy

14. An expendable pattern is used in
   a. slush casting
   b. squeeze casting
   c. centrifugal casting
   d. investment casting

15. The main purpose of spheroid sing treatment is to improve
   a. hardneability of low carbon steels
   b. machinability of low carbon steels
   c. hardenabiity of high carbon steels
   d. machinability of high carbon steels

16. NC contouring is an example of
   a. continuous path positioning
   b. point-to-point positioning
   c. absolute positioning
   d. incremental positioning

17. A ring gauge is used to measure
   a. outside diameter but not roundness
   b. roundness but not outside diameter
   c. both outside diameter and roundness
   d. only external threads

18. The number of customers arriving at a railway reservation counter is Poisson distributed with an arrival rate of eight customers per hour. The reservation clerk at this counter takes six minutes per customer on an average with an exponentially distributed service time. The

average number of the customers in the queue will be

a. 3
b. 3.2
c. 4
d. 4.2

19. In an MRP system, component demand is

a. forecasted
b. established by the master production schedule
c. calculated by the MRP system from the master production schedule
d. ignored

TWO MARKS QUESTIONS

20. Eigenvalues of a matrix $S = \begin{bmatrix} 3 & 3 \\ 2 & 3 \end{bmatrix}$ are 5 and 1. What are the eigenvalues of the matrix $S^2 = SS$?

a. 1 and 25
b. 6 and 4
c. 5 and l
d. 2 and 10

21. Equation of the line normal to function $f(x) = (x - 8)^{2/3} + 1$ at P(0, 5) is

a. y = 3x - 5
b. y = 3x + 5
c. 3y = x + 15
d. 3y = x - 15

22. Assuming $i = \sqrt{-1}$ and t is a real number, $\int_0^{\pi/3} e^{it} dt$ is

a. $\frac{\sqrt{3}}{2} + i\frac{1}{2}$
b. $\frac{\sqrt{3}}{2} - i\frac{1}{2}$
c. $\frac{1}{2} + i\frac{\sqrt{3}}{2}$
d. $\frac{1}{2} + i\left(1 - \frac{\sqrt{3}}{2}\right)$

23. If $f(x) = \frac{2x^2 - 7x + 3}{5x^2 - 12x - 9}$, then $\lim_{x \to 3} f(x)$ will be

a. -1/3
b. 5/18
c. 0
d. 2/5

24. Match the items in columns I and II.

Column I

P. Singular matrix
Q. Non-square matrix
R. Real symmetric
S. Orthogonal matrix

Column II

1. Determinant is not defined
2. Determinant is always one
3. Determinant is zero
4. Eigenvalues are always real
5. Eigenvalues are not defined

Codes;

a. P-3, Q-1, R-4, S-2
b. P-2, Q-3, R-4, S-1
c. P-3, Q-2, R-5, S-4
d. P-3, Q-4, R-2, S-1

25. For $\frac{d^2y}{dx^2} + 4\frac{dy}{dx} + 3y = 3e^{2x}$, the particular integrals is

a. $\frac{1}{15}e^{2x}$
b. $\frac{1}{5}e^{2x}$
c. $3e^{2x}$
d. $C_1e^{-x} + C_2e^{-3x}$

26. Multiplication of matrices E and F is G Matrices E and G are:

$E \equiv \begin{bmatrix} \cos\theta & -\sin\theta & 0 \\ \sin\theta & \cos\theta & 0 \\ 0 & 0 & 1 \end{bmatrix}$ and $G \equiv \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$.

What is the matrix F?

a. $\begin{bmatrix} \cos\theta & -\sin\theta & 0 \\ \sin\theta & \cos\theta & 0 \\ 0 & 0 & 1 \end{bmatrix}$
b. $\begin{bmatrix} \cos\theta & \cos\theta & 0 \\ -\cos\theta & \sin\theta & 0 \\ 0 & 0 & 1 \end{bmatrix}$
c. $\begin{bmatrix} \cos\theta & \sin\theta & 0 \\ -\sin\theta & \cos\theta & 0 \\ 0 & 0 & 1 \end{bmatrix}$

d. $\begin{bmatrix} \sin\theta & -\cos\theta & 0 \\ \cos\theta & \sin\theta & 0 \\ 0 & 0 & 1 \end{bmatrix}$

27. Consider the continuous random variable with probability density function

$$f(t) = 1+t \quad for \ -1 \le t \le 0$$
$$= 1-t \quad for \ \ 0 \le t \le 1$$

The standard deviation of the random variable is

a. $\frac{1}{\sqrt{3}}$

b. $\frac{1}{\sqrt{6}}$

c. $\frac{1}{3}$

d. $\frac{1}{6}$

28. If a system is in equilibrium and the position of the system depends upon many independent variables, the principle of virtual work states that the partial derivatives of its total potential energy with respect to each of the independent variable must be

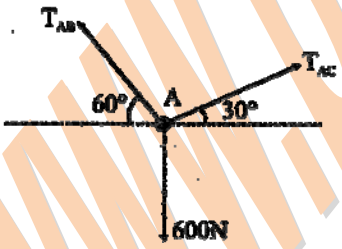
a. -1.0

b. 0

c. 1.0

d. ∞

29. If point A is in equilibrium under the action of the applied forces, the values of tensions T_{AB} and T_{AC} are respectively.



a. 520 N and 300 N

b. 300 N and 520 N

c. 450 N and 150 N

d. 150 N and 450 N

30. According to Von-Mises' distortion energy theory, the distortion energy under three dimensional stress state is represented by

a. $\frac{1}{2E}\left[\sigma_1^2+\sigma_2^2-2\nu\left(\sigma_1\sigma_2+\sigma_3\sigma_2+\sigma_1\sigma_3\right)\right]$

b. $\frac{1-2\nu}{6E}\left[\sigma_1^2+\sigma_2^2+\sigma_3^2+2\left(\sigma_1\sigma_2+\sigma_3\sigma_2+\sigma_1\sigma_3\right)\right]$

c. $\frac{1+\nu}{3E}\left[\sigma_1^2+\sigma_2^2+\sigma_3^2-\left(\sigma_1\sigma_2+\sigma_3\sigma_2+\sigma_1\sigma_3\right)\right]$

d. $\frac{1}{3E}\left[\sigma_1^2+\sigma_2^2+\sigma_3^2-\nu\left(\sigma_1\sigma_2+\sigma_3\sigma_2+\sigma_1\sigma_3\right)\right]$

31. A steel bar of 40 mm × 40 mm square cross-section is subjected to an axial compressive load of 200 kN. If the length of the bar is 2 m and E = 200 GPa, the elongation of the bar will be

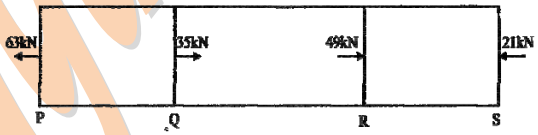
a. 1.25 mm

b. 2.70 mm

c. 4.05 mm

d. 5.40 mm

32. A bar having a cross-sectional area of 700 mm^2 is subjected to axial loads at the positions indicated. The value of stress in the segment QR is



a. 40 MPa

b. 50 MPa

c. 70 MPa

d. 120 MPa

Statement for linked Answer

Questions 33 & 34:

A simply supported beam of span length 6 m and 75 mm diameter carries a uniformly distributed load of 1.5 kN/m,

33. What is the maximum value of bending moment'?

a. 9 kNm

b. 13.5 kNm

c. 81 kNm

d. 125 kNm

34. What is the maximum value of bending stress?

a. 162.98 MPa

b. 325.95 MPa

c. 625.95 MPa

d. 651.90 MPa

35. Match the items in columns I and II.

Column I

P. Addendum

Q. Instantaneous center of velocity

R. Section modulus

S. Prime circle

Column II

1. Cam
2. Beam
3. Linkage
4. Gear

a. P-4, Q-2, R-3, S-1

b. P-4, Q-3, R-2, S-1

c. P-3, Q-2, R-l, S-4

d. P-3, Q-4, R-1, S-2

36. If C_f is the coefficient of speed fluctuation of a flywheel then the ratio of $\omega_{max}/\omega_{min}$ will be

a. $\frac{1-2C_f}{1+2C_f}$

b. $\frac{1-2C_f}{2+C_f}$

c. $\frac{1+2C_f}{1-2C_f}$

d. $\frac{2+2C_f}{2-C_f}$

37. Match the items in columns I and II

Column I

A. P. Higher kinematics pair

B. Q. Lower kinematics pair

C. R. Quick return mechanism

D. S. Mobility of a linkage

Column II

1. Grubler's equation
2. Line contact
3. Euler's equation
4. Planer
5. Shaper
6. Surface contact

a. P-2, Q-6, R-4, S-3

b. P-6, Q-2, R-4, S-1

c. P-6, Q-2, R-5, S-3

d. P-2, Q-6, R-5, S-1

38. A machine of 250 kg mass is supported on springs of total stiffness 100 kN/m. Machine has an unbalanced rotating force of 350N at speed of 3600 rpm. Assuming a damping factor of 0.15, the value of transmissibility ratio is

a. 0.0531

b. 0.9922

c. 0.0162

d. 0.0028

39. In a four-bar linkage, S denotes the shortest link length, L is the longest link length, P and Q are the lengths of other two links. At least one of the three moving links will rotate by 360° if

a. $S+L \le P+Q$

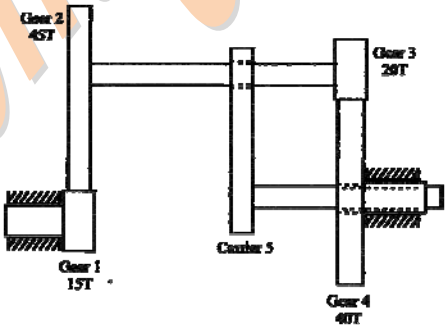
b. $S+L > P+Q$

c. $S+P \le L+Q$

d. $S+P > L+Q$

Common Data for Questions 40 & 41:

A planetary gear train has four gears and one carrier. Angular velocities of the gears are $\omega_1, \omega_2, \omega_3,$ *and* $\omega_4,$ respectively. The carrier rotates with angular velocity



40. What is the relation between the angular velocities of Gear 1 and Gear 4?

a. $\frac{\omega_1-\omega_5}{\omega_4-\omega_5}=6$

b. $\frac{\omega_4-\omega_5}{\omega_1-\omega_5}=6$

c. $\frac{\omega_1-\omega_2}{\omega_4-\omega_5}=\left(\frac{2}{3}\right)$

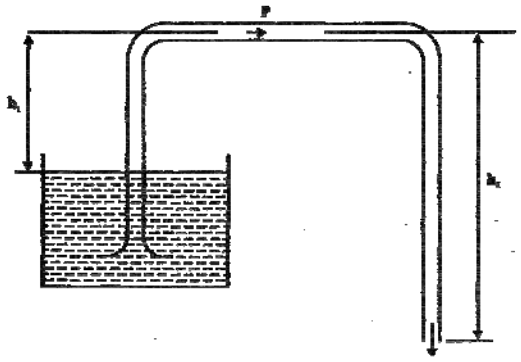
d. $\frac{\omega_2-\omega_5}{\omega_4-\omega_5}=\frac{8}{9}$

41. For ω_1 = 60 rpm clockwise (cw) when looked from the left, what is the angular velocity of the carrier and its direction so that Gear 4 rotates in counterclockwise (ccw) direction at twice the angular velocity of Gear I when looked from the left?
    a. 130 rpm, cw
    b. 223 rpm, ccw
    c. 256 rpm, cw
    d. 156 rpm, ccw

Statement for linked Answer
Questions 42 & 43:

A vibratory system consists of a mass l2 kg, a spring of stillness 1000 N/m, and a dashpot with damping coefficient of 15N s/m.

42. The value of critical damping of the system is
    a. 0.223 Ns/m
    b. 17.88 Na/m
    c. 71.4 Ns/m
    d. 223.6 Na/m.
43. The value of logarithmic decrement is
    a. 1.35
    b. 1.32
    c. 0.68
    d. 0.66
44. A disk clutch is required to transmit 5kW at 2000 rpm. The disk has a friction lining with coefficient of friction equal to 0.25. Bore radius of friction lining is equal to 25mm, Assume uniform contact pressure of 1 MPa. The value of outside radius of the friction lining is
    a. 39.4 mm
    b. 49.5 mm
    c. 97.9 mm
    d. 142.9mm
45. Twenty degree full depth in volute profiled 19-tooth pinion and 37-tooth gear are in mesh. If the module is 5 mm, the center distance between the gear pair will be
    a. 140 mm
    b. l50 mm
    c. 280 mm
    d. 300 mm
46. A cylindrical shaft is subjected to an alternating stress of 100 MPa. Fatigue strength to sustain 1000 cycles is 490 MPa. If the corrected endurance strength is 70 MPa, estimated shaft life will be
    a. 1071 cycles
    b. 15000 cycles
    c. 281914 cycles
    d. 928643 cycles
47. A 60 mm long and 6 mm thick fillet weld carries a steady load of 15 kN along the weld. The shear strength of the weld material is equal to 200 MPa. The factor of safety is
    a. 2.4
    b. 3.4
    c. 4.8
    d. 6.8
48. A two-dimensional flow field has velocities along the x and y directions given by u = x^2t and v = -2xyt respectively, where t is time. The equation of streamline is
    a. x^2y = constant
    b. xy^2 = constant
    c. xy = constant
    d. not possible to determine
49. The velocity profile in filly developed laminar flow in a pipe of diameter D is given by $u = u_0\left(1-4r^2/D^2\right)$, where r is the radial distance from the center, If the viscosity of the fluid is μ the pressure drop across a length L of the pipe is
    a. $\frac{\mu u_0 L}{D^2}$
    b. $\frac{4\mu u_0 L}{D^2}$
    c. $\frac{8\mu u_0 L}{D^2}$
    d. $\frac{16\mu u_0 L}{D^2}$
50. A siphon draws water from a reservoir and discharge it out at atmospheric pressure Assuming ideal fluid and the reservoir is large, the velocity at point P in the siphon tube is



a. $\sqrt{2gh_1}$

b. $\sqrt{2gh_2}$

c. $\sqrt{2g(h_2-h_1)}$

d. $\sqrt{2g(h_2+h_1)}$

51. A large hydraulic turbine is to generate 300 kW at 1000 rpm under a head of 40 m, For initial testing, a 1: 4 scale model of the turbine operates under a head of 10m, The power generated by the model (in kW) will he

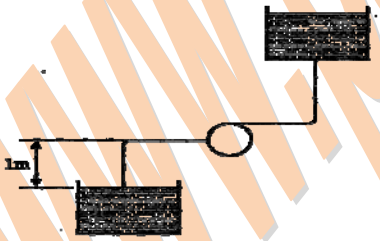
a. 2.34

b. 4.68

c. 9.38

d. 18.75

52. A horizontal - shaft centrifugal pump lifts water at 65°C. The suction nozzle is one meter below pump centerline. The pressure at this point equals 200 kPa gauges and velocity is 3 m/s. Steam tables show saturation pressure at 65°C is 25 kPa, and specific volume of the saturated liquid is 0.001020 m^3/kg. The pump Net Positive Suction Head (NPSH) in meters is



a. 24

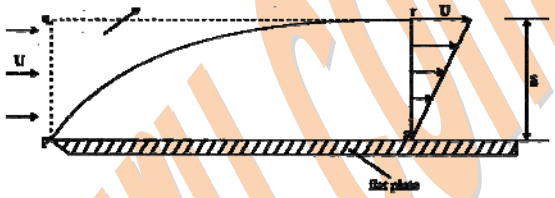
b. 26

c. 28

d. 30

Statement for Linked Answer Questions 53 & 54.

A smooth flat plate with a sharp leading edge is placed along a gas stream flowing at U 10 m/s. The thickness of the boundary layer at section r-s is 10 mm, the breadth of the plate is 1 m (into the paper) and the density of the gas p 1.0 kg/m^3. Assume that the boundary layer is thin, two-dimensional, and follows a linear velocity distribution, u = U (y/δ), at the section r-s, where y is the height from plate.



53. The mass flow rate (in kg/s) across the section q-r is

a. zero

b. 0.05

c. 0.10

d. 0.15

54. The integrated drag force (in N) on the plate. between p-s, is

a. 0.67

b. 0.33

c. 0.17

d. zero

55. A 100W electric bulb was switched on in a 2.5m × 3m × 3m size thermally insulated room having a temperature of 20°C. The room temperature at the end of 24 hours will be

a. 321°C

b. 341°C

c. 450°C

d. 470°C

56. A thin layer of water in a field in formed after a farmer has watered it. The ambient air conditions are: temperature 20°C and relative humidity 5%.

An extract of steam tables is given below,

Temperature (°C)	-15	-10	-05	0.01	5	10	15	20
Saturation Pressure (kPa)	0.10	0.26	0.40	0.61	0.87	1.23	1.71	2.34

Neglecting the heat transfer between the water and the ground, the water temperature in the filed after phase equilibrium is reached equals

a. 10.3°C
b. -10.3°C
c. -14.5°C
d. 14.5°C

57. With an increase in the thickness of insulation around a circular pipe, heat loss to surrundings due to

a. convection increases, while that due to conduction decreases
b. convection decreases, while that due to conduction increases
c. convection and conduction decreases
d. convection and conduction increases

58. Given below is an extract from steam tables.

Temperature °C	P_{sat} (Bar)	Specific Volume (m^3/kg)		Enthalpy (kJ/kg)	
		Saturated liquid	Saturated Vapour	Saturated liquid	Saturated vapour
45	0.09593	0.001011	15.26	188.45	2594.8
342.24	150	0.001658	0.1018337	1610.5	2610.5

Specific enthalpy of water in kJ/kg at 150 bar and 45°C is

a. 203.60
b. 200.53
c. 196.38
d. 188.45

59. Determine the correctness or otherwise Assertion (A) and the Reason (R).

Assertion (A): In a power plant working on a Rankine cycle, the regenerative feed water heating improves the efficiency of the steam turbine.

Reason (R): The regenerative feed water heating raises the average temperature of heat addition in the Rankine cycle.

An extract of steam tables is given below.

a. Both (a) and (r) are true and (r) is the correct reason for (a)
b. Both (a) and (r) are ture but (r) is NOT the correct reason for (a)
c. Both (a) and (r) are false
d. (a) is false but (r) is true

60. Determine the correctness or otherwise of the following Assertion (a) and the Reason (r).

Assertion (A) : Condenser is an essential equipment in a steam power plant.

Reason (R) : For the same mass flow rate and the same pressure rise, a water pump requires substantially less power than a steam compressor.

a. Both (a) and (r) are true and (r) is the correct reason for (a)
b. Both (a) and (r) are ture but (r) is NOT the correct reason for (a)
c. Both (a) and (r) are false
d. (a) is false but (r) is true

61. Match items from groups I, II, III, IV and V.

Group I	Group II	Group III	Group IV	Group V
	When added to the system, is	Differential	Function	Phenomenon
E - Heat	G Positive	I Exact	K Path	M Transient
F Work	H Negative	J Inexact	L Point	N Boundary

a. F-G-J-K-M
E-G-I-K-N
b. E-G-I-K-M
F-H-I-K-N
c. F-H-J-L-N
E-H-I-L-M
d. E-G-J-K-N
F-H-J-K-M

62. Group I shows different heat addition processes in power cycles. Likewise, Group II shows different heat removal processes. Group III lists power cycles. Match items from Groups I, II and III.

Group I	Group II	Group III
P. Pressure constant	S. Pressure constant	1. Rankine cycle
Q. Volume Constant	T. Volume Constant	2. Otto cycle
R. Temperature constant	U. Temperature constant	3. Carnot cycle
		4. Diesel cycle
		5. Brayton cycle

a. P-S-5
R-U-3
P-S-1
Q-T-2
b. P-S-1
R-U-3

P-S-4
P-T-2'

c. R-T-3
P-S-1
P-T-4
Q-S-5

d. P-T-4
R-S-3
P-S-1
P-S-5

Statement for Linked Answer
Questions 63 & 64

A football was inflated to a gauge pressure of 1 bar when the ambient temperature was 15°C. When the game started next day, the air temperature at the stadium was 5°C. Assume that the volume of the football remains constant at 2500 cm^3.

63. The amount of heat lost by the air in the football and the gauge pressure of air in the football at the stadium respectively equal
a. 30.6 3, 1.94 bar
b. 21.8 3, 0.93 bar
c. 61.1 3, 1.94 bar
d. 43.7 3, 0.93 bar

64. Gauge pressure of air to which the ball must have been originally inflated so that it would be equal 1 bar gauge at the stadium is
a. 2.23 bar
b. 1.94 bar
c. 1.07 bar
d. 1.00 bar

65. The statements concern psychometric chart.
1. Constant relative humidity lines are uphill straight lines to the right
2. Constant wet bulb temperature lines are downhill straight lines to the right
3. Constant specific volume lines are downhill straight lines to the right
4. Constant enthalpy lines are coincident with constant wet bulb temperature lines

Which of the statements are correct?
a. 2 and 3
b. 1 and 2
c. 1 and 3
d. 2 and 4

66. The ultimate tensile strength of a material is 400 MPa and the elongation up to maximum load is 35%. If the material obeys power law of hardening, then the true stress-true strain relation (stress in MPa) in the plastic deformation range is
a. $\sigma = 540\varepsilon^{0.30}$
b. $\sigma = 775\varepsilon^{0.30}$
c. $\sigma = 540\varepsilon^{0.35}$
d. $\sigma = 775\varepsilon^{0.35}$

67. In a sand casting operation, the total liquid head is maintained constant such that it is equal to the mould height. The time taken to fill the mould with a top gate is t_A. If the same mould is filled with a bottom gate, then the time taken is t_B. Ignore the time required to fill the runner and frictional effects. Assume atmospheric pressure at the top molten metal surfaces. The relation between t_A and t_B is
a. $t_B = \sqrt{2}t_A$
b. $t_B = 2t_A$
c. $t_B = \frac{t_A}{\sqrt{2}}$
d. $t_B = 2\sqrt{2}t_A$

68. A 4mm thick sheet is rolled with 300mm diameter rolls to reduce thickness without any change in its width. The friction coefficient at the work-roll interface is 0.1. The minimum possible thickness of the sheet that can be produced in a single pass is
a. 1.0mm
b. 1.5mm
c. 2.5mm
d. 3.7mm

69. In a wire drawing operation, diameter of a steel wire is reduced from 10mm to 8 mm. The mean flow stress of the material is 400 MPa. The ideal force required for drawing (ignoring friction and redundant work) is
a. 4.48 kN
b. 8.97 kN
c. 20.11 kN
d. 31.41 kN

70. Match the items in columns land II
Column-I
P - Wrinkling
Q - Orange peel
R - Stretcher strains
S - Earing
Column-II
1. Yield point elongation

2. Anisotropy
3. Large grain
4. Insufficient blank holding force
5. Fine grain size
6. Excessive blank holding force

a. P-6, Q-3, R-l, S-2
b. P-4, Q-5, R-6, S-1
c. P-2, Q-5, R-3, S-I
d. P-4, Q-3, R-1, S-2

71. In an arc welding process, the voltage and current are 25 V and 300 A respectively. The arc heat transfer efficiency is 0.85 and welding speed is 8 mm/sec. The net heat input (in J/mm)is.
a. 64
b. 797
c. 1103
d. 79700

72. If each abrasive grain is viewed as cutting tool, then which of the following represents the cutting parameters in common grinding operations?
a. Large negative rake angle, low shear angle and high cutting speed
b. Large positive rake angle, low shear angle and high cutting speed
c. Large negative rake angle, high shear angle and low cutting speed
d. Zero rake angle, high shear angle and high cutting speed

73. Arrange the processes in the increasing order of their maximum material removal rate.
Electrochemical Machining (ECM)
Ultrasonic Machining (USM)
Electron Beam Machining (EBM)
Laser Beam Machining (LBM)
Electric Discharge Machining (EDM)
a. USM, LBM, EBM, EDM, ECM
b. EBM, LBM, USM, ECM, EDM
c. LBM, EBM, USM, ECM, EDM
d. LBM, EBM, USM, EDM, ECM

74. Match the items in columns land II.
Column-I
P-Charph test
Q-Knoop
R-Spiral test
S-Cupping test
Column-II
1. Fluidity
2. Micro hardness
3. Formability
4. Toughness
5. Permeability

a. P-4, Q-5, R-3, S-2
b. P-3, Q-5, R-l, S-4
c. P-2, Q-4, R-3, S-5
d. P-4, Q-2, R-l, 5-3

Common Data for Question 75, 76 & 77
In an orthogonal machining operation:
Uncut thickness = 0.5 mm
Cutting speed 20 m/min
Rake angle = 15°
Width of cut = 5 mm
Chip thickness = 0.7 mm
Thrust force = 200 N
Cutting force 1200 N
Assume Merchant's theory.

75. The values of shear angle and shear strain, respectively, are
a. 30.3° and 1.98°
b. 30.3° and 4.23°
c. 40.2° and 2.97°
d. 40.2° and 1.65°

76. The coefficient of friction at the tool-chip interface is
a. 0.23
b. 0.46
c. 0.85
d. 0.95

77. The percentage of total energy dissipated due to friction at the tool-chip interface is
a. 30%
b. 42%
c. 58%
d. 70%

78. A manufacturing shop processes sheet metal jobs, wherein each job must pass through two machines (M_l and M_2, in that order). The processing time (in hours) for these jobs is

Machine	Jobs					
	P	Q	R	S	T	U
M1	15	32	8	27	11	16
M2	6	19	13	20	14	7

The optimal make-span (in hours) of the shop is
a. 120

b. 115
c. 109
d. 79

79. Consider the following data for an item.
Annual demand: 2500 units per year
Ordering cost: Rs. 100 per order
Inventory holding rate: 25% of unit price
Price quoted by a supplier

Order quantity (units)	Units Price (Rs.)
< 500	10
> 500	9

The optimum order quantity (in units) is
a. 447
b. 471
c. 500
d. ≥ 600

80. A firm is required to procure three items (P, Q, and R). The prices quoted for these items (in Rs.) by suppliers S1, S2 and S3 are given in table. The management policy requires that each item has to be supplied by only one supplier and one supplier supply only one item. The minimum total cost (in Rs.) of procurement to the firm is

Item	Suppliers		
	S1	S2	S3
P	110	120	130
Q	115	140	140
R	125	145	165

a. 350
b. 360
c. 385
d. 395

81. A stockiest wish to optimize the number of perishable items he needs to stock in any month in his store. the demand distribution for this perishable item is

Demand (in units)	2	3	4	5
Probability	0.10	0.35	0.35	0.20

The stockiest pays Rs. 70 for each item and he sells each at P.s. 90. If the stock is left unsold
in any month, he can sell the item at Rs, 50 each. There is no penalty for unfulfilled demand.
To maximize the expected profit, the optimal stock level is
a. 5 units
b. 4 units
c. 3 units
d. 2 units

82. The table gives details of an assembly line.

Work Station	**I**	**II**	**III**	**IV**	**V**	**VI**
Total task time at the workstation (in minutes)	7	9	7	10	9	6

What is the line efficiency of the assembly line?
a. 70%
b. 75%
c. 80 %
d. 85%

Statement for Linked Answer Questions 83 & 84

Consider a PERT network for a project involving six tasks (a to f)

Task	Predecessor	Expected task time (in days)	Variance of the task time (in $days^2$)
a	-	30	25
b	a	40	64
c	a	60	81
d	b	25	9
e	b, c	45	36
f	d, e	20	9

83. The expected completion time of the project is
a. 238 days
b. 224 days
c. 171 days
d. 155 days

84. The standard deviation of the critical path of the project is
a. $\sqrt{151}$ days
b. $\sqrt{155}$ days
c. $\sqrt{200}$ days
d. $\sqrt{238}$ days

MECHANICAL ENGINEERING

ONE MARKS QUESTIONS

1. The minimum value of function $y = x^2$ in the interval [1, 5] is
   a. 0
   b. 1
   c. 25
   d. undefined

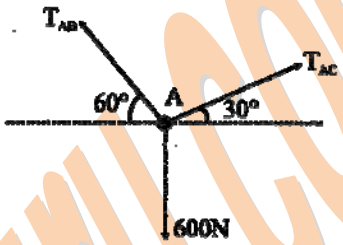
2. If a square matrix A is real and symmetric, then the eigenvalues
   a. are always real
   b. are always real and positive
   c. are always real and non-negative
   d. occur in complex conjugate pairs

3. If φ (x, y) and ψ (x, y) are functions with continuous second derivatives, then φ (x, y) + iψ (x, y) can be expressed as an analytic function of $x + i\psi\left(i - \sqrt{-1}\right)$, when
   a. $\frac{\partial\varphi}{dx} = \frac{\partial\psi}{\partial x}, \frac{\partial\varphi}{\partial y} = \frac{\partial\psi}{\partial y}$
   b. $\frac{\partial\varphi}{dy} = -\frac{\partial\psi}{\partial x}; \frac{\partial\varphi}{\partial x} = \frac{\partial\psi}{\partial y}$
   c. $\frac{\partial^2\varphi}{\partial x^2} + \frac{\partial^2\varphi}{\partial y^2} = \frac{\partial^2\psi}{\partial x^2} + \frac{\partial^2\psi}{\partial y^2} = 1$
   d. $\frac{\partial\varphi}{\partial x} + \frac{\partial\varphi}{\partial y} = \frac{\partial\psi}{\partial x} + \frac{\partial\psi}{\partial y} = 0$

4. The partial differential equation $\frac{\partial^2\varphi}{\partial x^2} + \frac{\partial^2\varphi}{\partial y^2} + \left(\frac{\partial\varphi}{\partial x}\right) + \left(\frac{\partial\varphi}{\partial y}\right) = 0$ has
   a. degree 1 order 2
   b. degree 1 order 1
   c. degree 2 order 1
   d. degree 2 order 2

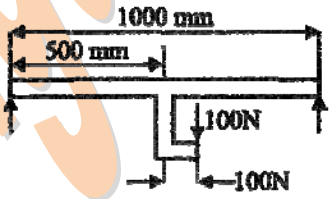
5. If a system is in equilibrium and the position of the system depends upon many independent variables, the principle of virtual work states that the partial derivatives of its total potential energy with respect to each of the independent variable must be
   a. -1.0
   b. 0
   c. 1.0
   d. ∞

6. If point A is in equilibrium under the action of the applied forces, the values of tensions T_{AB} and T_{AC} are respectively.



   a. 520 N and 300 N
   b. 300 N and 520 N
   c. 450 N and 150 N
   d. 150 N and 450 N

7. In a simply-supported beam loaded as shown below, the maximum bending moment in Nm is



   a. 25
   b. 30
   c. 35
   d. 60

8. A steel rod of length L and diameter D, fixed at both ends, is uniformly heated to a temperature rise of ΔT. The Young's modulus is E and the coefficient of linear expansion isα. The thermal stress in the rod is
   a. 0
   b. αT
   c. EαΔT
   d. EαΔTL

9. For an under damped harmonic oscillator, resonance
   a. occurs when excitation frequency is greater than undamped natural frequency
   b. occurs when excitation frequency in less than undamped natural frequency
   c. occurs when excitation frequency is equal to undamped natural frequency

d. never occurs

10. A ball bearing operating at a load F has 8000 hours of life. The life of the bearing, in hours, when the load is doubled to 2F is
    a. 8000
    b. 6000
    c. 4000
    d. 1000

11. Consider an incompressible laminar boundary layer flow over a flat plate of length L, aligned with the direction of an oncoming uniform free stream, If F is the ratio of the drag force on the front half of die plate to the drag force the rear half, then
    a. F < l/2
    b. F = l/2
    c. F = 1
    d. F > 1

12. In a steady flow through a nozzle, the flow velocity on the nozzle axis is given by v = u_0 (l + 3x/L)i, where x is the distance along the axis of the nozzle from its inlet plane and L is the length of the nozzle, The time required for a fluid particle on the axis to travel from the inlet to the exit plane of the nozzle is
    a. $\frac{L}{u_0}$
    b. $\frac{L}{3u_0} In4$
    c. $\frac{L}{4u_0}$
    d. $\frac{L}{2.5u_0}$

13. Consider steady laminar incompressible axi-symmetric fully developed viscous flow through a straight circular pipe of constant cross-sectional area at a Reynolds number of 5. The ratio of inertia force to viscous force on a fluid particle is
    a. 5
    b. 1/5
    c. 0
    d. ∞

14. Which of the following relationships is valid only for reversible processes undergone by a closed system of simple compressible substance (neglect changes in kinetic and potential energy)?
    a. δQ = dU + δW
    b. T dS = dU + p dV
    c. T dS = dU + δW
    d. δQ = dU + p dV

15. Water has a critical specific volume of 0.003155 m^3/kg. A closed and rigid steel tank of volume 0.025 m^3 contains a mixture of water and steam at 0.1 MPa. The mass of the mixture is 10kg. The tank is now slowly heated. The liquid level inside the tank
    a. will rise
    b. will fail
    c. will remain constant
    d. may rise or fall depending on the amount of heat transferred

16. If a particular Fe-C alloy contains less than 0.83% carbon, it is called
    a. High speed steel
    b. hypereutectoid steel
    c. hypereutectoid steel
    d. cast iron

17. Which of the following engineering materials is the most suitable candidate for hot chamber die casting?
    a. low carbon steel
    b. titanium
    c. copper
    d. tin

18. Which one of the following is a solid state joining process?
    a. gas tungsten arc welding
    b. resistance spot welding
    c. friction welding
    d. submerged arc welding

19. In orthogonal turning of a low carbon steel bar of diameter 150mm with uncoated carbide tool, the cutting velocity is 90 m/mm. The feed is 0.24 mm/rev and the depth of cut is 2 mm. The chip thickness obtained is 0.48 mm. If the orthogonal rake angle is zero and the principal cutting edge angle is 90°, the shear angle in degree is
    a. 20.56
    b. 26.56
    c. 30.56
    d. 36.56

20. Which type of motor is NOT used in axis or spindle drives of CNC machine tools?
    a. induction motor
    b. dc servo motor
    c. stepper motor

d. linear servo motor

21. Volume of a cube of side '*l*' and volume of a sphere of radius '*r*' are equal. Both the cube and the sphere are solid and of same material. They are being cast. The ratio of the solidification time of the cube to the same of sphere is

a. $\left(\frac{4\pi}{6}\right)^3\left(\frac{r}{i}\right)^6$

b. $\left(\frac{4\pi}{6}\right)\left(\frac{r}{i}\right)^2$

c. $\left(\frac{4\pi}{6}\right)^2\left(\frac{r}{i}\right)^3$

d. $\left(\frac{4\pi}{6}\right)^2\left(\frac{r}{i}\right)^4$

TWO MARKS QUESTIONS

22. If, $y = x + \sqrt{x + \sqrt{x + \sqrt{x + ...\infty}}}$, then y(2) =

a. 4 or 1
b. 4 only
c. 1 only
d. undefined

23. The area of a triangle formed by the tips of vectors $\bar{a}, \bar{b}$ *and* $\bar{c}$ is

a. $\frac{1}{2}(\bar{a}-\bar{b}).(\bar{a}-\bar{c})$

b. $\frac{1}{2}|(\bar{a}-\bar{b})\times(\bar{a}-\bar{c})$

c. $\frac{1}{2}|\bar{a}\times\bar{b}\times\bar{c}|$

d. $\frac{1}{2}(\bar{a}\times\bar{b}).\bar{c}$

24. The solution of $\frac{dy}{dx} = y^2$ with initial value y(0) =1 bounded in the interval

a. $-\infty \le x \le 8$
b. $-\infty \le x \le 1$
c. $x < 1, x > 1$
d. $-2 \le x \le 2$

25. If F(s) is the Laplace transform of function f(t), then Laplace transform of $\int_0^t f(\tau)d\tau$ is

a. $\frac{1}{s}F(s)$

b. $\frac{1}{s}F(s) - f(0)$

c. $sF(s) - f(0)$

d. $\int F(s)ds$

26. A calculator has accuracy up to 8 digits after decimal place. The value of $\int_0^{2\pi} \sin x\, dx$ when evaluated using this calculator by trapezoidal method with 8 equal intervals, to 5 significant digits is

a. 0.00000
b. 1.0000
c. 0.00500
d. 0.00025

27. Let X and Y be two independent random variables, Which one of the relations between expectation (E), variabce (Var) and covariance (Cov) given below is FALSE?

a. E (XY) = E (X) E (Y)
b. Cov (X, Y) =0
c. Var(X + Y) = Var (X) + Var (Y)
d. $E(X^2Y^2) = (E(X))^2(E(Y))^2$

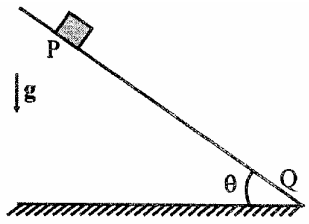
28. $\lim_{x\to 0}\frac{e^x - \left(1 + x + \frac{x^2}{2}\right)}{x^3} =$

a. 0
b. 1/6
c. 1/3
d. 1

29. The number of linearly independent eigenvectors of $\begin{bmatrix} 2 & 1 \\ 0 & 2 \end{bmatrix}$ is

a. 0
b. 1
c. 2
d. infinite

30. A block of mass M is released from point P on a rough inclined plane with inclination angle θ, shown in the figure below. The coefficient of friction is μ. If μ < tan θ, then the time taken by the block to reach another point Q on the inclined plane, where PQ = s, is



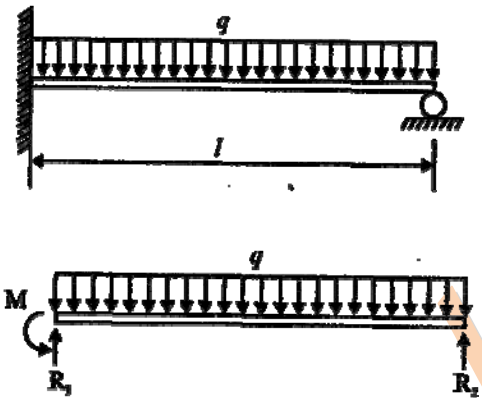
a. $\sqrt{\frac{2s}{g\cos\theta(\tan\theta - \mu)}}$

b. $\sqrt{\frac{2s}{g\cos\theta(\tan\theta+\mu)}}$

c. $\sqrt{\frac{2s}{g\sin\theta(\tan\theta-\mu)}}$

d. $\sqrt{\frac{2s}{g\sin\theta(\tan\theta+\mu)}}$

31. A uniformly loaded propped cantilever beam and its free body diagram is shown below. The reactions are



a. $R_1=\frac{5ql}{8}, R_2=\frac{3ql}{8}, M=\frac{ql^2}{8}$

b. $R_1=\frac{3ql}{8}, R_2=\frac{5ql}{8}, M=\frac{ql^2}{8}$

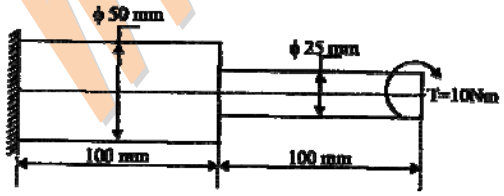
c. $R_1=\frac{5ql}{8}, R_2=\frac{3ql}{8}, M=0$

d. $R_1=\frac{3ql}{8}, R_2=\frac{5ql}{8}, M=0$

32. A 200 × 100 × 50 mm steel block is subjected to a hydrostatic pressure of 15 MPa. The Young's modulus and Poisson's ratio of the material are 200 GPa and 0.3 respectively. The change in the volume of the block in mm^3 is

a. 85
b. 90
c. 100
d. 110

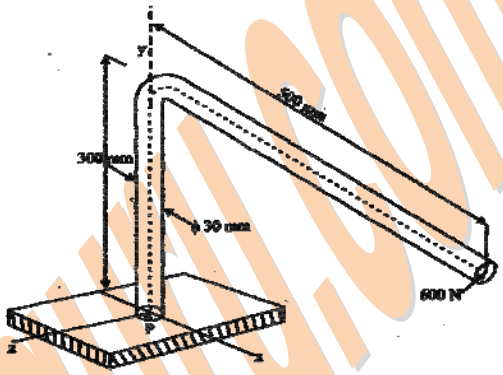
33. A stepped steel shaft shown below is subjected to 10 Nm torque. If the modulus of rigidity is 80 GPa, the strain energy in the shaft in N mm is



a. 4.12
b. 3.46
c. 1.73
d. 0.86

Statement for Linked Answer Questions 34 & 35:

A machine frame shown in the figure below is subjected to a horizontal force of 600 N parallel to z-direction.



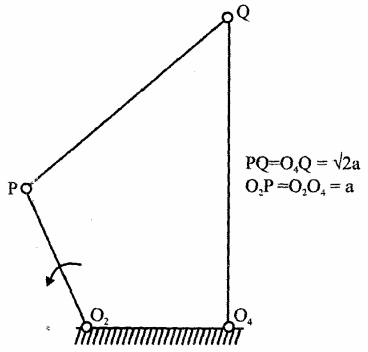
34. The normal and shear stresses in MPa at point P are respectively

a. 67.9 and 56.6
b. 56.6 and 67.9
c. 67.9 and 0.0
d. 0.0 and 56.6

35. The maximum principal stress in MPa and the orientation of the corresponding principal plane in degrees are respectively

a. -32.0 and -29.52
b. 100.0 and 60.48
c. -32,0 and 60.48
d. 100.0 and -2952

36. The input link O_2P of a four bar lin1 age is rotated at 2 rad/s in counter clockwise direction as shown below, The angular velocity of the coupler PQ in rad/s, at an instant when $\angle O_4O_2P = 180°$, is

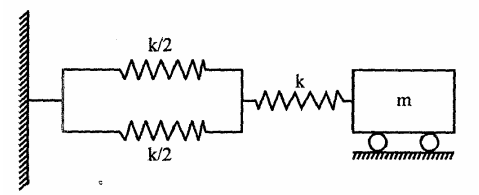


a. 4
b. $2\sqrt{2}$
c. 1

d. $1\sqrt{2}$

37. The speed of an engine varies from 210 rad/s to 190 rad/s. During cycle the change in kinetic energy is found to be 400 Nm. The inertia of the flywheel in kgm^2 is
a. 0.10
b. 0.20
c. 0.30
d. 0.40

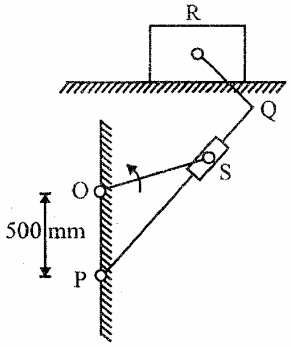
38. The natural frequency of the system shown below is



a. $\sqrt{\frac{k}{2m}}$
b. $\sqrt{\frac{k}{m}}$
c. $\sqrt{\frac{2k}{m}}$
d. $\sqrt{\frac{3k}{m}}$

39. The equation of motion of a harmonic oscillator is given by $\frac{d^2x}{dt^2} + 2\xi\omega_2\frac{dx}{dt} + \omega_n^2 x = 0$ and the initial conditions at t = 0 are x(0) = X, $\frac{dx}{dt}(0) = 0$. The amplitude of x(t) after n complete cycles is
a. $Xe^{-2n\pi\left(\frac{\xi}{\sqrt{1-\xi^2}}\right)}$
b. $Xe^{2n\pi\left(\frac{\xi}{\sqrt{1-\xi^2}}\right)}$
c. $Xe^{-2n\pi\left(\frac{\sqrt{1-\xi^2}}{\xi}\right)}$
d. X

Statement for Linked Answer Questions 40-41:
A quick return mechanism is shown below. The crank OS is driven at 2 rev/s in counters clockwise direction.



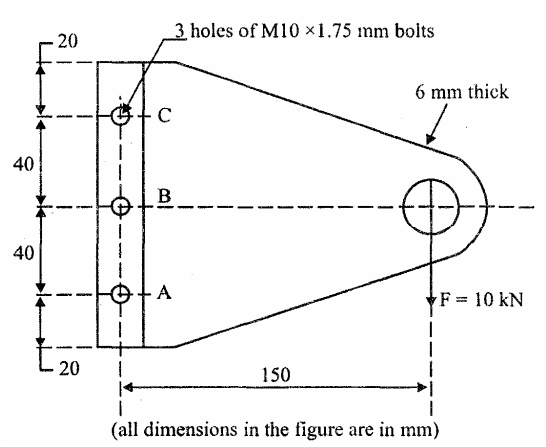
40. If the quick return ratio is 1: 2, then the length of the crank in mm is
a. 250
b. $250\sqrt{3}$
c. 500
d. $500\sqrt{3}$

41. The angular speed of PQ in rev/s when the block R attains maximum speed during forward stroke (stroke with slower speed) is
a. 1/3
b. 2/3
c. 2
d. 3

42. A thin spherical pressure vessel of 200 mm diameter and 1 mm thickness is subjected to an internal pressure varying from 4 to 8 MPa. Assume that the yield, ultimate, and endurance strength of material are 600, 800 and 400 MPa respectively. The factor of safety as per Goodman's relation is
a. 2.0
b. l.6
c. 1.4
d. 1.2

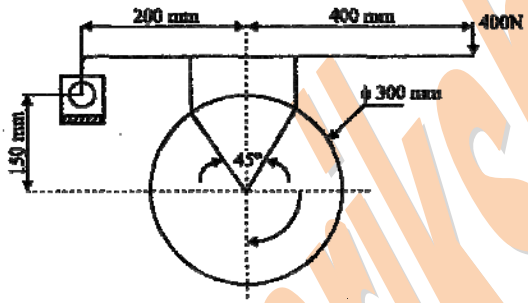
43. A natural feed journal bearing of diameter 50 mm and length 50 mm operating at 20 revolution/sec. carries a load of 2.0 kN. The lubricant used has a viscosity of 20 MPa/s. The radial clearance is 50 μm. The sommerfield number for the bearings is
a. 0.062
b. 0.125
c. 0.250
d. 0.785

44. A bolted joint is shown below. The maximum shear stress, in MPa, in the bolts at A and B, respectively are



a. 242.6, 42.5
b. 42.5, 242.6
c. 42.5, 42.5
d. 242.6, 242.6

45. A block-brake shown below has a face width of 300mm and a mean coefficient of friction of 0.25. For an activating force of 400 N, the braking torque in Nm is



a. 30
b. 40
c. 45
d. 60

46. The piston rod of diameter 20 mm and length 700 mm in a hydraulic cylinder is subjected to a compressive force of 10 kN due to the internal pressure. The end conditions for the rod may be assumed as guided at the piston end and hinged at the other end. The Young's modulus is 200 GPa. The factor of safety for the piston rod is
a. 0.68
b. 2.75
c. 5.62
d. 11.0

Statement for Linked Answer Questions 47 to 49:

A gear set has a pinion with 20 teeth and a gear with 40 teeth. The pinion runs at 30rev/s and transmits a power of 20 kW. The teeth are on the 20° full-depth system and have a module of 5mm. The length of the line of action is 19mm.

47. The center distance for the above gear set in mm is
a. 140
b. 150
c. 160
d. 170

48. The contact ratio of the contacting tooth is
a. 1.21
b. 1.25
c. 1.29
d. 1.33

49. The resultant force on the contacting gear tooth is N is
a. 77.23
b. 212.20
c. 225.80
d. 289.43

50. The inlet angle of runner blades of a Francis turbine is 90°. The blades are so shaped that the tangential component of velocity at blade outlet is zero. The flow velocity remains constant throughout the blade passage and is equal to half of the blade velocity at runner inlet. The blade efficiency of the runner is
a. 25%
b. 50%
c. 80%
d. 89%

51. A model of a hydraulic turbine is tested at a head of $1/4^{th}$ of that under which the full scale turbine works. The diameter of the model is half of that of the full scale turbine. If N is the RPM of the full scale turbine, then the RPM of the model will be
a. N/4
b. N/2
c. N
d. 2N

52. Which combination of the following statements about steady incompressible forced vortex flow is correct?
P: Shear stress is zero at all points in the flow.
Q: Vorticity is zero at all points in the flow.
R: Velocity is directly proportional to the radius from the centre of the vorted.

S: Total mechanical energy per unit mass is constant in the entire flow field.

a. P and Q
b. R and S
c. P and R
d. P and S

53. Match the items in columns I and II.

Column I

P: Centrifugal compressor
Q: Centrifugal pump
R: Pelton wheel
S: Kaplan turbine

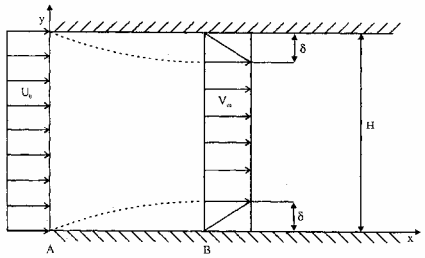
Column II

1. Axial flow
2. Surging
3. Priming
4. Pure impulse

a. P-2, Q-3, R-4, S-1
b. P-2, Q-3, R-1, S-4
c. P-3, Q-4, R-1, S-2
d. P-1, Q-2, R-3, S-4

Statement for linked Answer Questions 54 & 55

Consider a steady incompressible flow through a channel as shown below.



The velocity profile is uniform with a value of u_0 at the inlet section A. The velocity profile at section B downstream is

$$u = \begin{cases} V_m \dfrac{y}{\delta}, & 0 \le y \le \delta \\ V_m, & \delta \le y \le H-\delta \\ V_m \dfrac{H-y}{\delta}, & H-\delta \le y \le H \end{cases}$$

54. The ratio V_m/u_0 is

a. $\dfrac{1}{1-2(\delta/H)}$
b. 1
c. $\dfrac{1}{1-(\delta/H)}$
d. $\dfrac{1}{1+(\delta/H)}$

55. The ratio $\dfrac{p_A - p_B}{\frac{1}{2}\rho u_0^2}$ (where P_A and P_B are the pressures at section A arid B, respectively, and ρ is the density of the fluid) is

a. $\dfrac{1}{(1-(\delta/H))^2} - 1$
b. $\dfrac{1}{[1-(\delta/H)]^2}$
c. $\dfrac{1}{(1-(2\delta/H))^2} - 1$
d. $\dfrac{1}{1+(\delta/H)}$

56. The temperature distribution within the thermal boundary layer over a heated isothermal flat plate is given by $\dfrac{T-T_W}{T_\infty - T_W} = \dfrac{3}{2}\left(\dfrac{y}{\delta_t}\right) - \dfrac{1}{2}\left(\dfrac{y}{\delta_t}\right)^3$, where T_W and T_∞. are the temperatures of plate and free stream respectively, and y is the normal distance measured from the plate. The local Nusselt number based on the thermal boundary layer thickness δ_t is given by

a. 1.33
b. 1.50
c. 2.0
d. 4.64

57. In a counter flow heat exchanger, hot fluid enters at 60°C and cold fluid leaves at 30°C. Mass flow rate of the hot fluid is 1 kg/s and that the cold fluid is 2 kg/s. Specific heat of the hot fluid is 10kJ/kgK and that of the cold fluid is 5 kJ/kgK. The Log Mean Temperature Difference (LMTD) for the heat exchanger in °C is

a. 15
b. 30
c. 35
d. 45

58. The average heat transfer coefficient on a thin hot vertical plate suspended in still air can be determined from observations of the change in plate temperature with time as it cools. Assume the plate temperature to be uniform at any instant of time and radiation heat exchange with the surroundings negligible. The ambient temperature is 25°C, the plate has a total surface area of 0.1 m^2 and a mass of 4 kg. The specific heat of the plate material is 2.5 kJ/kgK. The convective heat transfer

coefficient in W/m^2K, at the instant when the plate temperature is 225°C and the change in plate temperature with time dT/dt = -0.02 K/s, is

a. 200
b. 20
c. 15
d. 10

59. A heat transformer is device that transfers a part of the heat, supplied to it at an intermediate temperature, to a high temperature reservoir while rejecting the remaining part to a low temperature heat sink. In such a heat transformer, 100 kJ of heat is supplied at 350 K. The maximum amount of heat in kJ that can be transferred to 400 K, when the rest is rejected to a heat sink at 300K is

a. 12.50
b. 14.29
c. 33.33
d. 57.14

Statement for linked Answer Questions 60 & 61:

Consider steady one-dimensional heat flow in a plate of 20 mm thickness with a uniform heat generation of 80 MW/m^3. The left and right faces are kept at constant temperatures of 160°C and 120°C respectively. The plate has a constant thermal conductivity of 200 W/mK.

60. The location of maximum temperature within the plate from its left face is

a. 15 mm
b. 10 mm
c. 5 mm
d. 0 mm

61. The maximum temperature within the plate is °C is

a. 160
b. 165
c. 200
d. 250

62. The stroke and bore of a four stroke spark ingition engine are 250mm and 200 mm respectively. The clearance volume is 0.001 m^3. If the specific heat ratio $\gamma = 1.4$, the air- standard cycle efficiency of the engine is

a. 46. 40%
b. 56.10%
c. 58.20%
d. 62.80%

63. Which combination of the following statements is correct?

The incorporation of reheater in a steam power plant:

P: always increases the thermal efficiency of the plant.

Q: always increases the dryness fraction of steam at condenser inlet.

R: always increases the mean temperature of heat addition.

S: always increases the specific work output.

a. P and S
b. Q and S
c. P, R and S
d. P, Q, R and S

64. Which combination of the following statements is correct?

P: A gas cools upon expansion only when its Joule - Thomson coefficient is positive in the temperature range of expansion.

Q: For a system undergoing a process, its entropy remains constant only when the process is reversible.

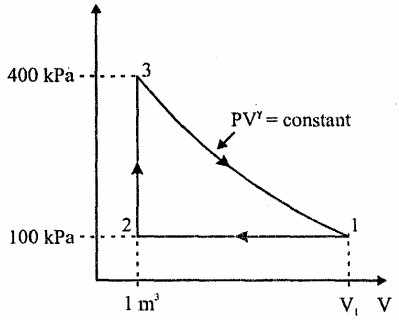
R: The work done by a closed system in an adiabatic is a point function.

S: A liquid expands upon freezing when the slope of its fusion curve on pressure-temperature diagram is negative.

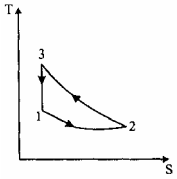
a. R and S
b. P and Q
c. Q, R and S
d. P, Q and R

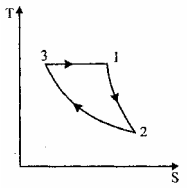
Common data for questions 65 & 66

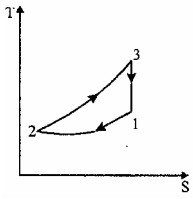
A thermodynamic cycle with an ideal gas as working fluid is shown below

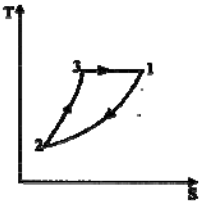


65. The above cycle is represented on T-S plane by

a. 

b. 

c. 

d. 

66. If the specific heats of the working fluid are constant and the value of specific heat ratio is 1.4, the thermal efficiency (%) of the cycle is
   a. 21
   b. 40.9
   c. 42.6
   d. 59.7

67. A building has to be maintained at 21°C (dry bulb) and 14.5°C (wet bulb). The dew point temperature under these conditions is 10.17°C. The outside temperature is -23°C (dry bulb) and the internal and external surface heat transfer coefficients are 8 W/m^2K and 23W/m^2K respectively. If the building wall has a thermal conductivity of 1.2 W/mK, the minimum thickness (in m) of the wall required to prevent condensation is
   a. 0.471
   b. 0.407
   c. 0.321
   d. 0.125

68. Atmospheric air at a flow rate of 3 kg/s (on dry basis) enters a cooling and dehumidifying coil with an enthalpy of 85 kJ/kg of dry air and a humidity ratio of 19 grams/kg of dry air. The air leaves the coil with an enthalpy of 43 kJ/kg of dry air and a humidity ratio of 8 grams 7kg of dry air. If the condensate water leaves the coil with an enthalpy of 67 kJ/kg, the required cooling capacity of the coil in kW is
   a. 75.0
   b. 123.8
   c. 128.2
   d. 159.0

69. In electro discharge machining (EDM), if the thermal conductivity of tools is high and the specific heat of work piece is low, then the tool wear rate and material removal rate are expected to be respectively
   a. high and high
   b. low and low
   c. high and low
   d. low and high

70. In orthogonal turning of medium carbon steel, the specific machining energy is 2.0 J/mm^3. The cutting velocity, feed and depth of cut are 120 m/mm, 0.2 mm/rev and 2mm respectively. The main cutting force in N is
   a. 40
   b. 80
   c. 400
   d. 800

71. A direct current welding machine with a linear power source characteristic provides open circuit voltage of 80V and short circuit current of 800 A. During welding with the machine, the measured arc current is 500 A corresponding to an arc length of 5.0 mm and the measured arc current is 460 A corresponding to an arc length of 7.0 mm. The linear voltage (E)-arc length (L)-characteristic of the welding arc can be given as (where E is in Volt and L is in mm)
   a. E = 20 + 2 L
   b. E = 20 + 8L
   c. E = 80 + 8L
   d. E = 80 + 2L

72. A hole is specified as $40^{0.050}_{0.000}$ mm. The mating shall has a clearance fit with minimum clearance of 0.01mm. The tolerance on the shaft is 0.04mm. The maximum clearance in mm between the hole and the shaft is
   a. 0.04
   b. 0.05

c. 0.10
d. 0.11

73. In orthogonal turning of low carbon steel pipe with principal cutting edge angle of 90°, the main cutting force is 1000 N and the feed force is 800 N. The shear angle is 25° and orthogonal rake angle is zero. Employing Merchant's theory, the ratio of friction force to normal force acting on the cutting tool is
a. l.56
b. l.25
c. 0.80
d. 0.64

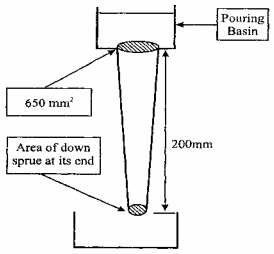
74. Two metallic sheets, each of 2.0 mm thickness, are welded in a lap joint configuration by resistance spot welding at a welding current of 10 kA and welding time of 10 millisecond. A spherical fusion zone extending up to the full thickness of each sheet is formed a properties of the metallic sheets are given as:
ambient temperature = 293 K
melting temperature = 1793 K
density = 7000 kg/m^3
latent heat of fusion = 300 kJ/kg
specific heat 800 J/kgK
Assume: (i) contact resistance along sheet-interface is 500 micro-ohms and along electrode- sheet interface is zero; (ii) no conductive heat loss through the bulk sheet materials; and (iii) the complete weld fusion zone is at the melting temperature.
The melting efficiency (in %) of the process is
a. 50.37
b. 60.37
c. 70.37
d. 80.37

75. In open-die forging, a disc of diameter 200mm and height 60 mm is compressed without any barreling effect. The final diameter of the disc is 400 mm. The true strain is
a. 1.986
b. 1.686
c. 1.386
d. 0.602

76. The thickness of a metallic sheet is reduced from an initial value of 16mm to a final value of 10mm in one single pass rolling with a pair of cylindrical rollers each of diameter of 400 mm. The bite angle in degree will be
a. 5.936
b. 7.936
c. 8.936
d. 9.936

77. Match the correct combination for following metal working processes.
Processes
P - Blanking
Q - Stretch Forming
R - Coining
S - Deep Drawing
Associated state of stress
1. Tension
2. Compression
3. Shear
4. Tension and Compression
5. Tension and shear
a. P-2, Q-1, R-3, S-4
b. P-3, Q-4, R-1, S-S
c. P-5, Q-3, R-3, S-1
d. P-3, Q-1, R-2, S-4

78. A 200 mm long down sprue has an are of cross-section of 650 mm^2 where the pouring basin meets the down sprue (i.e. at the beginning of the down sprue). A constant head of molten metal is maintained by the pouring basin. The moltan metal flow rate is 6.5 × l0 mm^3/s. Considering the end of down sprue to be open to atmospere and an acceleration due to gravity of 1 0 mm/s^2, the area of the down sprue in mm^2 at its end (avoiding aspiration effect) should be



a. 650.0
b. 350.0
c. 5.0
d. 190.0

79. The force requirement in a blanking operation of low carbon steel sheet is 5.0 kN. The thickness of the sheet is't' and diameter of the blanked part is'd'. For the same work material, if the diameter of the blanked part is increased to 1.5 d and

thickness is reduced to 0.4t, the new blanking force in kN is

a. 3.0
b. 4.5
c. 290.7
d. 8,0

80. Match the most suitable manufacturing processes for the following parts.

Parts

A. P-Computer chip
B. Q-Metal forming dies and molds
C. R-.Turbine blade
D. S-Glass

Manufacturing Processes

1. Electrochemical Machining
2. Ultrasonic Machining
3. Electro discharge Machining
4. Photochemical Machining

a. P-4, Q-3, R-l, S-2
b. P-4, Q-3, R-2, S-1
c. P-3, Q-1 R-4, S-2
d. P-1 Q-2, R-4, S-3

Statement for Linked Answer Question 81-82:

A low carbon steel bar of 147mm diameter with a length of 630mm is being turned with uncoated carbide insert. The observed tool lives are 24 mm and 12 mm for cutting velocities of 90mlmin and 120 m/mm respectively. The feed and depth of cut are 0.2 mm/rev and 2 mm respectively. Use the unashamed diameter to calculate the cutting velocity.

81. What tool life is 20 mm, the cutting velocity in m/min is

a. 87
b. 97
c. 107
d. 114

82. Neglect over-travel or approach of the tool. When tool life is 20 mm, the machining time in mm for a single pass is

a. 5
b. 10
c. 15
d. 20

83. Capacities of production of an item over 3 consecutiv3e months in regular time are 100, 100 and 80 and in overtime are 20, 20 and 40. The demands over those 3 months are 90, 130 and 110. The cost of production in regular time and overtime are respectively Rs. 20 per item and Rs. 24 per item. Inventory carrying cost is Rs. 2 per item month. The levels of starting and final inventory are nil. Backorder is not permitted. For minimum cost of plan, the level of planned production in overtime in the third month is

a. 40
b. 30
c. 20
d. 0

84. The maximum level of inventory of an item 100 and it is achieved with infinite replenishment rate. The inventory becomes zero over one and half month due to consumption at a uniform rate. This cycle continues throughout the year. Ordering cost is Rs. 100 per order and inventory carrying cost is Rs. 10 per item per month. Annual cost (in Rs.) of the plan, neglecting material cost, is

a. 800
b. 2800
c. 4800
d. 6800

85. In machine shop, pins of 15 mm diameter are produced at a rate of 1000 per month and the same is consumed at a rate of 500 per month. The production and consumption continue simultaneously till the maximum inventory is reached. Then inventory is allowed to reduce to zero due to consumption. The lot size of production is 1000. If backlog is not allowed, the maximum inventory level is

a. 400
b. 500
c. 600
d. 700

86. The net requirements of an it m over 5 consecutive weeks are 50-0-15-20-20. The inventory carrying cost and ordering cost are Re. 1 per item per week and Rs. 100 per order respectively. Starting inventory is zero. Use “Least Unit Cost Technique” for developing the plan. The cost of the plan (in Rs.) is

a. 200
b. 250
c. 225
d. 260

GATE : 2008

ME : Mechanical Engineering

Duration : Three Hours *Maximum Marks : 150*

Read the following instructions carefully

1. Using HB pencil, darken the appropriate bubble under each digit of your registration number and the letters corresponding to your paper code.

2. All the questions in this question paper are of objective type.

3. Questions must be answered on Objective Response Sheet (**ORS**) by darkening the appropriate bubble (marked A, B, C, D) using HB pencil against the question number on the left hand side of the ORS. **Each question has only one correct answer.** In case you wish to change an answer, erase the old answer completely. More than one answer bubbled against a question will be treated as a wrong answer.

4. Questions 1 through 20 are 1-mark questions and questions 21 through 85 are 2-mark questions.

5. Questions 71 through 73 is one set of common data questions, questions 74 and 75 is another pair of common data questions. The question pairs (76, 77), (78, 79), (80, 81), (82, 83) and (84, 85) are questions with linked answers. The answer to the second question of the above pairs will depend on the answer to the first question of the pair. If the first question in the linked pair is wrongly answered or is un-attempted, then the answer to the second question in the pair will not be evaluated.

6. Un-attempted questions will carry zero marks.

7. **NEGATIVE MARKING:** For Q.1 to Q.20, ***0.25*** mark will be deducted for each wrong answer. For Q.21 to Q.75, ***0.5*** mark will be deducted for each wrong answer. For the pairs of questions with linked answers, there will be negative marks only for wrong answer to the first question, i.e; for Q.76, Q.78, Q.80, Q.82 and Q.84, ***0.5*** mark will be deducted for each wrong answer. There is no negative marking for Q.77, Q.79, Q.81, Q.83 and Q.85.

8. Calculator **without data connectivity** is allowed in the examination hall.

9. Charts, graph sheets and tables are NOT allowed in the examination hall.

10. Rough work can be done on the question paper itself. Additional blank pages are given at the end of the question paper for rough work.

Q.1 – Q.20 carry one mark each.

1. In the Taylor series expansion of e^x about $x = 2$, the coefficient of $(x - 2)^4$ is

   (a) $1/4!$ (b) $2^4/4!$

   (c) $e^2/4!$ (d) $e^4/4!$

2. Given that $\ddot{x} + 3x = 0$, and $x(0) = 1$, $\dot{x}(0) = 0$, what is $x(1)$?

   (a) -0.99 (b) -0.16

   (c) 0.16 (d) 0.99

3. The value of $\lim_{x \to 8} \frac{x^{1/3} - 2}{(x - 8)}$ is

   (a) $\frac{1}{16}$ (b) $\frac{1}{12}$

   (c) $\frac{1}{8}$ (d) $\frac{1}{4}$

4. A coin is tossed 4 times. What is the probability of getting heads exactly 3 times?

   (a) $\frac{1}{4}$ (b) $\frac{3}{8}$

   (c) $\frac{1}{2}$ (d) $\frac{3}{4}$

5. The matrix $\begin{bmatrix} 1 & 2 & 4 \\ 3 & 0 & 6 \\ 1 & 1 & p \end{bmatrix}$ has one eigenvalue equal to 3. The sum of the other two eigenvalues is

   (a) p (b) $p - 1$

   (c) $p - 2$ (d) $p - 3$

6. The divergence of the vector field $(x - y)\,\hat{i} + (y - x)\,\hat{j} + (x + y + z)\,\hat{k}$ is

   (a) 0 (b) 1

   (c) 2 (d) 3

7. The transverse shear stress acting in a beam of rectangular cross-section, subjected to a transverse shear load, is

   (a) variable with maximum at the bottom of the beam

   (b) variable with maximum at the top of the beam

   (c) uniform

   (d) variable with maximum of the neutral axis

8. A rod of length L and diameter D is subjected to a tensile load P. Which of the following is sufficient to calculate the resulting change in diameter?

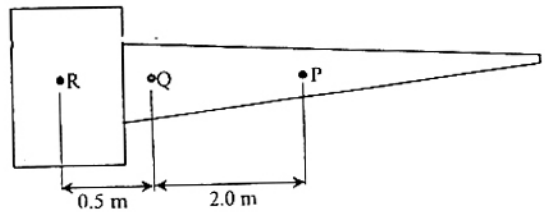
(a) Young's modulus
(b) Shear modulus
(c) Poisson's ratio
(d) Both Young's modulus and shear modulus

9. A straight rod of length L(t), hinged at one end and freely extensible at the other end, rotates through an angle $\theta(t)$ about the hinge. At time t, $L(t) = 1$ m, $\dot{L}(t) = 1$ m/s, $\theta(t) = \frac{\pi}{4}$ rad and $\dot{\theta}(t) = 1$ rad/s. The magnitude of the velocity at the other end of the rod is

(a) 1 m/s
(b) $\sqrt{2}$ m/s
(c) $\sqrt{3}$ m/s
(d) 2 m/s

10. A cantilever type gate hinged at Q is shown in the figure. P and R are the centers of gravity of the cantilever part and the counterweight respectively. The mass of the cantilever part is 75 kg. The mass of the counterweight, for static balance, is

(a) 75 kg
(b) 150 kg
(c) 225 kg
(d) 300 kg



11. A planar mechanism has 8 links and 10 rotary joints. The number of degrees of freedom of the mechanism, using Gruebler's criterion, is

(a) 0
(b) 1
(c) 2
(d) 3

12. An axial residual compressive stress due to a manufacturing process is present on the outer surface of a rotating shaft subjected to bending. Under a given bending load, the fatigue life of the shaft in the presence of the residual compressive stress is

(a) decreased
(b) increased or decreased, depending on the external bending load
(c) neither decreased nor increased
(d) increased

13. 2 moles of oxygen are mixed adiabatically with another 2 moles of oxygen in mixing chamber, so that the final total pressure and temperature of the mixture become same as those of the individual constituents at their initial states. The universal gas constant is given as R. The chang in entropy due to mixing, per mole of oxygen, is given by

(a) $-R \ln 2$
(b) 0
(c) $R \ln 2$
(d) $R \ln 4$

14. For flow of fluid over a heated plate, the following fluid properties are known

viscosity = 0.001 Pa.s ; specific heat at constant pressure = 1kj/kg.K ;

thermal conductivity = 1 W/m.k.

The hydrodynamic boundary layer thickness at a specified location on the plate is 1 mm. The thermal boundary layer thickness at the same location is

(a) 0.001 mm
(b) 0.01 mm
(c) 1 mm
(d) 1000 mm

15. For the continuity equation given by $\vec{\nabla} \bullet \vec{V} = 0$ to be valid, where $\vec{V}$ is the velocity vector, which one of the following is a necessary condition?

(a) steady flow
(b) irrotational flow
(c) inviscid flow
(d) incompressible flow

16. Which one of the following is NOT a necessary assumption for the air-standard Otto cycle?

(a) All processes are both internally as well as externally reversible.
(b) Intake and exhaust processes are constant volume heat rejection processes.
(c) The combustion process is a constant volume heat addition process.
(d) The working fluid is an ideal gas with constant specific heats.

17. In an M/M/1 queuing system, the number of arrivals in an interval of length T is a Poisson random variable (i.e. the probability of there being n arrivals in an interval of length T is $\frac{e^{-\lambda T}(\lambda T)^n}{n!}$).

The probability density function f(t) of the inter-arrival time is given by

(a) $\lambda^2 \left(e^{-\lambda^2 t} \right)$
(b) $\frac{e^{-\lambda^2 t}}{\lambda^2}$
(c) $\lambda e^{-\lambda t}$
(d) $\frac{e^{-\lambda t}}{\lambda}$

18. A set of 5 jobs is to be processed on a single machine. The processing time (in days) is given in the table below. The holding cost for each job is Rs. K per day.

Job	Processing time
P	5
Q	2
R	3
S	2
T	1

A schedule that minimizes the total inventory cost is

(a) T-S-Q-R-P
(b) P-R-S-Q-T
(c) T-R-S-Q-P
(d) P-Q-R-S-T

19. For generating a Coon's surface we require

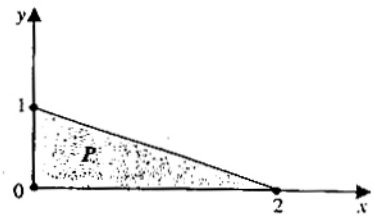
(a) a set of grid points on the surface
(b) a set of grid control points
(c) four bounding curves defining the surface
(d) two bounding curves and a set of grid control points

20. Internal gear cutting operation can be performed by

(a) milling
(b) shaping with rack cutter
(c) shaping with pinion cutter
(d) hobbing

Q.21 to Q.75 carry two marks each.

21. Consider the shaded triangular region P shown in the figure. What is $\iint_P xydxdy$?



(a) $\frac{1}{6}$

(b) $\frac{2}{9}$

(c) $\frac{1}{16}$

(d) 1

22. The directional derivative of the scalar function $f(x, y, z) = x^2 + 2y^2 + z$ at the point P = (1, 1, 2) in the direction of the vector $\vec{a} = 3\hat{i} - 4\hat{j}$ is

(a) -4 (b) -2

(c) -1 (d) 1

23. For what value of a, if any, will the following system of equations in x, y and z have a solution?

$$2x + 3y = 4$$
$$x + y + x = 4$$
$$x + 2y - z = a$$

(a) Any real number (b) 0

(c) 1 (d) There is no such value

24. Which of the following integrals is unbounded?

(a) $\int_0^{\frac{\pi}{4}} \tan x \, dx$ (b) $\int_0^{\infty} \frac{1}{x^2+1} dx$

(c) $\int_0^{\infty} xe^{-x} \, dx$ (d) $\int_0^{1} \frac{1}{1-x} dx$

25. The integral $\oint f(z)dz$ evaluated around the unit circle on the complex plane for $f(z) = \frac{\cos z}{z}$ is

(a) $2\pi i$ (b) $4\pi i$

(c) $-2\pi i$ (d) 0

26. The length of the curve $y = \frac{2}{3}x^{3/2}$ between x = 0 and x = 1 is

(a) 0.27 (b) 0.67

(c) 1 (d) 1.22

27. The eigenvectors of the matrix $\begin{bmatrix} 1 & 2 \\ 0 & 2 \end{bmatrix}$ are written in the form $\begin{bmatrix} 1 \\ a \end{bmatrix}$ and $\begin{bmatrix} 1 \\ b \end{bmatrix}$. What is a + b ?

(a) 0

(b) $\frac{1}{2}$

(c) 1

(d) 2

28. Let $f = y^x$. What is $\frac{\partial^2 f}{\partial x \partial y}$ at x = 2, y = 1 ?

(a) 0

(b) In 2

(c) 1

(d) $\frac{1}{\text{In } 2}$

29. It is given that $y'' + 2y' + y = 0$, $y(0) = 0$, $y(1) = 0$. What is $y(0.5)$?

(a) 0

(b) 0.37

(c) 0.62

(d) 1.13

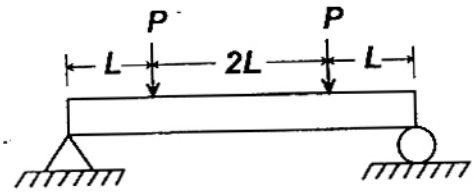
30. The strain energy stored in the beam with flexural rigidity FL and loaded as shown in the figure is

(a) $\frac{P^2 L^3}{3EI}$

(b) $\frac{2P^2 L^3}{3EI}$

(c) $\frac{4P^2 L^3}{3EI}$

(d) $\frac{8P^2 L^3}{3EI}$



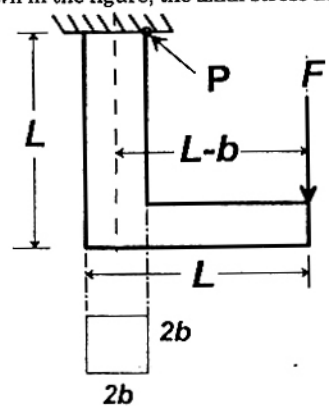
31. For the component loaded with a force F as shown in the figure, the axial stress at the corner point P is

(a) $\frac{F(3L - b)}{4b^3}$

(b) $\frac{F(3L + b)}{4b^3}$

(c) $\frac{F(3L + 4b)}{4b^3}$

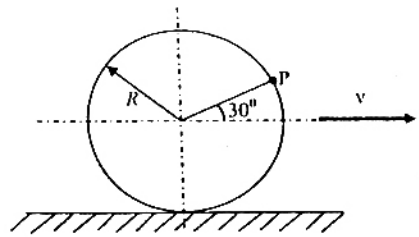
(d) $\frac{F(3L + 2b)}{4b^3}$



32. A solid circular shaft of diameter 100 mm is subjected to an axial stress of 50 MPa. It is further subjected to a torque of 10 kNm. The maximum principal stress experienced on the shaft is closest to

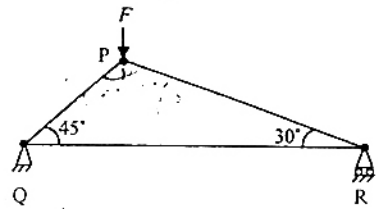
(a) 41 MPa
(b) 82 MPa
(c) 164 MPa
(d) 204 MPa

33. A circular disk of radius R rolls without slipping at a velocity v. The magnitude of the velocity at point P (see figure) is



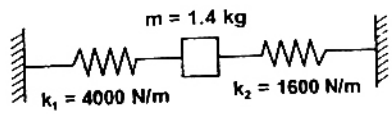
(a) $\sqrt{3}$ v
(b) $\sqrt{3}$ v/2
(c) v/2
(d) 2v/$\sqrt{3}$

34. Consider a truss PQR loaded at P with a force F as shown in the figure.
The tension in the member QR is



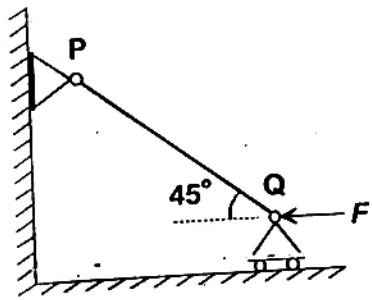
(a) 0.5 F
(b) 0.63 F
(c) 0.73 F
(d) 0.87 F

35. The natural frequency of the spring mass system shown in the figure is closest to



(a) 8 Hz
(b) 10 Hz
(c) 12 Hz
(d) 14 Hz

36. The rod PQ of length L and with flexural rigidity EI is hinged at both ends. For what minimum force F is it expected to buckle?



(a) $\frac{\pi^2 EI}{L^2}$
(b) $\frac{\sqrt{2}\pi^2 EI}{L^2}$
(c) $\frac{\pi^2 EI}{\sqrt{2}L^2}$
(d) $\frac{\pi^2 EI}{2L^2}$

37. In a cam design, the rise motion is given by a simple harmonic motion (SHM) $s = \frac{h}{2}\left(1 - \cos\frac{\pi\theta}{\beta}\right)$ where h is total rise, θ is camshaft angle, β is the total angle of the rise interval. The jerk is given by

(a) $\frac{h}{2}\left(1 - \cos\frac{\pi\theta}{\beta}\right)$

(b) $\frac{\pi}{\beta}\frac{h}{2}\sin\left(\frac{\pi\theta}{\beta}\right)$

(c) $\frac{\pi^2}{\beta^2}\frac{h}{2}\cos\left(\frac{\pi\theta}{\beta}\right)$

(d) $-\frac{\pi^3}{\beta^3}\frac{h}{2}\sin\left(\frac{\pi\theta}{\beta}\right)$

38. A uniform rigid rod of mass m = 1 kg and length L = 1 m is hinged at its centre and laterally supported at one end by a spring of spring constant k = 300 N/m. The natural frequency ω_n in rad/s is

(a) 10

(b) 20

(c) 30

(d) 40

39. A compression spring is made of music wire of 2 mm diameter having a shear strength and shear modulus of 800 MPa and 80 GPa respectively. The mean coil diameter is 20 mm, free length is 40 mm and the number of active coils is 10. If the mean coil diameter is reduced to 10 mm, the stiffness of the spring is approximately

(a) decreased by 8 times

(b) decreased by 2 times

(c) increased by 2 times

(d) increased by 8 times

40. A journal bearing has shaft diameter of 40 mm and a length of 40 mm. The shaft is rotating at 20 rad/s and the viscosity of the lubricant is 20 mPa.s. The clearance is 0.020 mm. The loss of torque due to the viscosity of the lubricant is approximately

(a) 0.040 Nm

(b) 0.252 Nm

(c) 0.400 Nm

(d) 0.652 Nm

41. A clutch has outer and inner diameters 100 mm and 40 mm respectively. Assuming a uniform pressure of 2 MPa and coefficient of friction of liner material 0.4, the torque carrying capacity of the clutch is

(a) 148 Nm

(b) 196 Nm

(c) 372 Nm

(d) 490 Nm

42. A spur gear has a module of 3 mm, number of teeth 16, a face width of 36 mm and a pressure angle of 20°. It is transmitting a power of 3 kW at 20 rev/s. Taking a velocity factor of 1.5, and a form factor of 0.3, the stress in the gear tooth is about

(a) 32 MPa

(b) 46 MPa

(c) 58 MPa

(d) 70 MPa

43. Match the type of gears with their most appropriate description.

	Type of gear		*Description*
P	Helical	1	Axes non parallel and non intersectin
Q	Spiral Bevel	2	Axes parallel and teeth are inclined to the axis
R	Hypoid	3	Axes parallel and teeth are parallel to the axis
S	Rack and pinion	4	Axes are perpendicular and intersecting, and teeth are inclined to the axis
		5	Axes are perpendicular and used for large speed reduction
		6	Axes parallel and one of the gears has infinite radius

(a) P-2, Q-4, R-1, S-6

(b) P-1, Q-4, R-5, S-6

(c) P-2, Q-6, R-4, S-2

(d) P-6, Q-3, R-1, S-5

44. A gas expands in a frictionless piston-cylinder arrangement. The expansion process is very slow, and is resisted by an ambient pressure of 100 kPa. During the expansion process, the pressure of the system (gas) remains constant at 300 kPa. The change in volume of the gas is 0.01 m^3. The maximum amount of work that could be utilized from the above process is

(a) 0 kJ (b) 1 kJ

(c) 2 kJ (d) 3 kJ

45. The logarithmic mean temperature difference (LMTD) of a counterflow heat exchanger is 20°C. The cold fluid enters at 20°C and the hot fluid enters at 100°C. Mass flow rate of the cold fluid is twice that of the hot fluid. Specific heat at constant pressure of the hot fluid is twice that of the cold fluid. The exit temperature of the cold fluid

(a) is 40°C (b) is 60°C

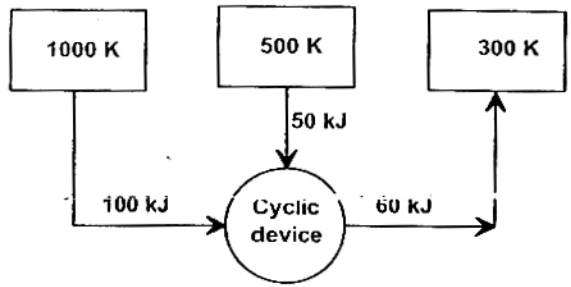
(c) is 80°C (d) cannot be determined

46. A two dimensional fluid element rotates like a rigid body. At a point within the element, the pressure is 1 unit. Radius of the Mohr's circle, characterizing the state of stress at that point, is

(a) 0.5 unit (b) 0 unit

(c) 1 unit (d) 2 unit

47. A cyclic device operates between three thermal reservoirs, as shown in the figure. Heat is transferred to/form the cyclic device. It is assumed that heat transfer between each thermal reservoir and the cyclic device takes place across negligible temperature difference. Interactions between the cyclic device and the respective thermal reservoirs that are shown in the figure are all in the form of heat transfer.



The cyclic device can be

(a) a reversible hear engine

(b) a reversible heat pump or a reversible refrigerator

(c) an irreversible heat engine

(d) an irreversible heat pump or an irreversible refrigerator

48. A balloon containing an ideal gas is initially kept in an evacuated and insulated room. The balloon ruptures and the gas fills up the entire room. Which one of the following statements is TRUE at the end of above process?

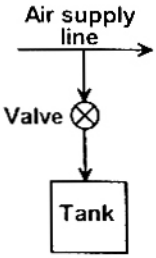
(a) The internal energy of the gas decreases from its initial value, but the enthalpy remains constant

(b) The internal energy of the gas increases from its initial value, but the enthalpy remains constant

(c) Both internal energy and enthalpy of the gas remain constant

(d) Both internal energy and enthalpy of the gas increase

49. A rigid, insulated tank is initially evacuated. The tank is connected with a supply line through which air (assumed to be ideal gas with constant specific heats) passes at 1 MPa, 350°C. A valve connected with the supply line is opened and the tank is charged with air until the final pressure inside the tank reaches 1 MPa. The final temperature inside the tank



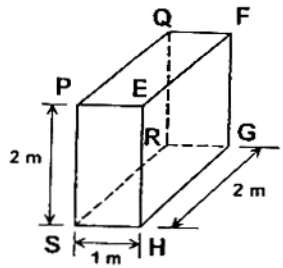
(a) is greater than 350°C

(b) is less than 350°C

(c) is equal to 350°C

(d) may be greater than, less than, or equal to 350°C, depending on the volume of the tank

50. For the three-dimensional object shown in the figure below, five faces are insulated. The sixth face (PQRS), which is not insulated, interacts thermally with the ambient, with a convective heat transfer coefficient of 10 W/m².K. The ambient temperature is 30°C. Heat is uniformly generated inside the object at the rate of 100 W/m³. Assuming the face PQRS to be at uniform temperature, its steady state temperature is



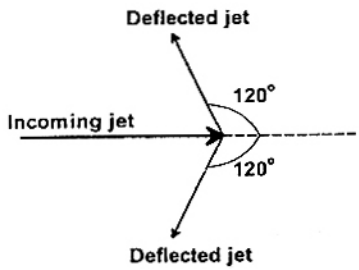
(a) 10°C

(b) 20°C

(c) 30°C

(d) 40°C

51. Water, having a density of 1000 kg/m³, issues from a nozzle with a velocity of 10 m/s and the jet strikes a bucket mounted on a Pelton wheel. The wheel rotates at 10 rad/s. The mean diameter of the wheel is 1 m. The jet is split into two equal streams by the bucket, such that each stream is deflected by 120°, as shown in the figure. Friction in the bucket may be neglected. Magnitude of the torque exerted by the water on the wheel, per unit mass flow rate of the incoming jet, is



(a) 0 (N.m)/(kg/s)

(b) 1.25 (N.m)/(kg/s)

(c) 2.5 (N.m)/(kg/s)

(d) 3.75 (N.m)/(kg/s)

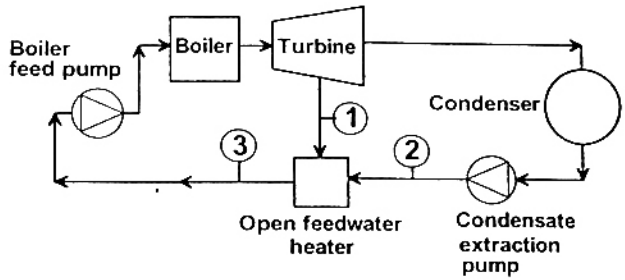
52. A thermal power plant operates on a regenerative cycle with a single open feedwater heater, as shown in the figure. For the state points shown, the specific enthalpies are: $h_1 = 2800$ kJ/kg and $h_2 = 200$ kJ/kg. The bleed to the feedwater heater is 20% of the boiler steam generation rate. The specific enthalpy at state 3 is

(a) 720 kJ/kg

(b) 2280 kJ/kg

(c) 1500 kJ/kg

(d) 3000 kJ/kg



53. Moist air at a pressure of 100 kPa is compressed to 500 kPa and then cooled to 35°C in an aftercooler. The air at the entry to the aftercooler is unsaturated and becomes just saturated at the exit of the aftercooler. The saturation pressure of water at 35°C is 5.628 kPa. The partial pressure of water vapour (in kPa) in the moist air entering the compressor is closest to

(a) 0.57

(b) 1.13

(c) 2.26

(d) 4.52

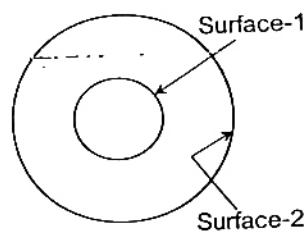
54. A hollow enclosure is formed between two infinitely long concentric cylinders of radii 1 m and 2 m, respectively. Radiative heat exchange takes place between the inner surface of the larger cylinder (surface-2) and the outer surface of the smaller cylinder (surface-1). The radiating surfaces are diffuse and the medium in the enclosure is non-participating. The fraction of the thermal radiation leaving the larger surface and striking itself is

(a) 0.25

(b) 0.5

(c) 0.75

(d) 1



55. Air (at atmospheric pressure) at a dry bulb temperature of 40°C and wet bulb temperature of 20°C is humidified in an air washer operating with continuous water recirculation. The wet bulb depression (i.e. the difference between the dry and wet bulb temperatures) at the exit is 25% of that at the inlet. The dry bulb temperature at the exit of the air washer is closest to

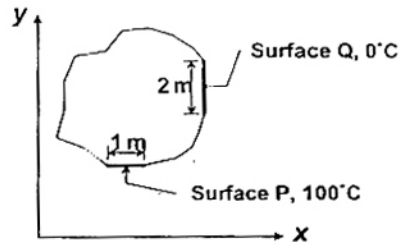
(a) 10°C

(b) 20°C

(c) 25°C

(d) 30°C

56. Steady two-dimensional heat conduction takes place in the body shown in the figure below. The normal temperature gradients over surfaces P and Q can be considered to be uniform. The temperature gradient $\frac{\partial T}{\partial x}$ at surface Q is equal to 10 K/m. Surfaces P and Q are maintained at constant temperatures as shown in the figure, while the remaining part of the boundary is insulated. The body has a constant thermal conductivity of 0.1 W/m.K. The values of $\frac{\partial T}{\partial x}$ and $\frac{\partial T}{\partial y}$ at surface P are



(a) $\frac{\partial T}{\partial x} = 20$ K/m, $\frac{\partial T}{\partial y} = 0$ K/m

(b) $\frac{\partial T}{\partial x} = 0$ K/m, $\frac{\partial T}{\partial y} = 10$ K/m

(c) $\frac{\partial T}{\partial x} = 10$ K/m, $\frac{\partial T}{\partial y} = 10$ K/m

(d) $\frac{\partial T}{\partial x} = 0$ K/m, $\frac{\partial T}{\partial y} = 20$ K/m

57. In a steady state steady flow process taking place in a device with a single inlet and a single outlet, the work done per unit mass flow rate is given by $w = -\int_{\text{inlet}}^{\text{outlet}} v\,dp$, where v is the specific volume and p is the pressure. The expression for w given above

(a) is valid only if the process is both reversible and adiabatic

(b) is valid only if the process is both reversible and isothermal

(c) is valid for any reversible process

(d) is incorrect; it must be $w = \int_{\text{inlet}}^{\text{outlet}} p\,dv$

58. For the standard transportation linear programme with m sources and n destinations and total supply equaling total demand, an optimal solution (lowest cost) with the smallest number of non-zero x_{ij} values (amounts from source i to destination j) is desired. The best upper bound for this number is

(a) mn (b) 2 (m + n)

(c) m + n (d) m + n − 1

59. A moving average system is used for forecasting weekly demand. $F_1(t)$ and $F_2(t)$ are sequences of forecasts with parameters m_1 and m_2, respectively, where m_1 and m_2 ($m_1 > m_2$) denote the numbers of weeks over which the moving averages are taken. The actual demand shows a step increase from d_1 to d_2 at a certain time. Subsequently,

(a) neither $F_1(t)$ nor $F_2(t)$ will catch up with the value d_2

(b) both sequences $F_1(t)$ and $F_2(t)$ will reach d_2 in the same period

(c) $F_1(t)$ will attain the value d_2 before $F_2(t)$

(d) $F_2(t)$ will attain the value d_2 before $F_1(t)$

60. For the network below, the objective is to find the length of the shortest path from node P to node G. Let d_{ij} be the length of directed are from node i to node j.

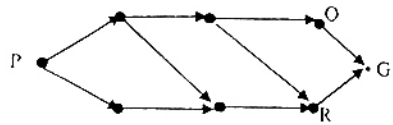
Let s_j be the length of the shortest path from P to node j. Which of the following equations can be used to find s_G?

(*a*) $s_G = \text{Min}\{s_Q, s_R\}$

(*b*) $s_G = \text{Min}\{s_Q - d_{QG}, s_R - d_{RG}\}$

(*c*) $s_G = \text{Min}\{s_Q + d_{QG}, s_R + d_{RG}\}$

(*d*) $s_G = \text{Min}\{d_{QG}, d_{RG}\}$



61. The product structure of an assembly P is shown in the figure.

Estimated demand for end product P is as follows

Week	1	2	3	4	5	6
Demand	1000	1000	1000	1000	1200	1200

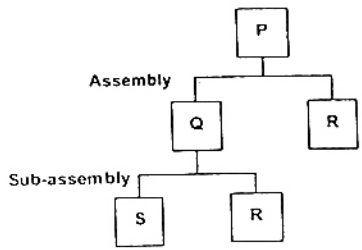
ignore lead times for assembly and sub-assembly. Production capacity (per week) for component R is the bottleneck operation. Starting with zero inventory, the smallest capacity that will ensure a feasible production plan up to week 6 is

(*a*) 1000

(*b*) 1200

(*c*) 2200

(*d*) 2400



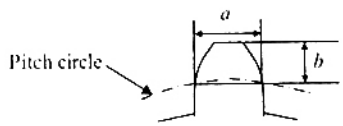
62. One tooth of a gear having 4 module and 32 teeth is shown in the figure. Assume that the gear tooth and the corresponding tooth space make equal intercepts on the pitch circumference. The dimensions 'a' and 'b', respectively, are closest to

(*a*) 6.08 mm, 4 mm

(*b*) 6.48 mm, 4.2 mm

(*c*) 6.28 mm, 4.3 mm

(*d*) 6.28 mm, 4.1 mm



63. While cooling, a cubical casting of side 40 mm undergoes 3%, 4% and 5% volume shrinkage during the liquid state, phase transition and solid state, respectively. The volume of metal compensated from the riser is

(*a*) 2%

(*b*) 7%

(*c*) 8%

(*d*) 9%

64. In a single point turning tool, the side rake angle and orthogonal rake angle are equal. φ is the principal cutting edge angle and its range is $0° \le \varphi \le 90°$. The chip flows in the orthogonal plane. The value of φ is closest to

(*a*) 0°

(*b*) 45°

(*c*) 60°

(*d*) 90°

65. A researcher conducts electrochemical machining (ECM) on a binary alloy (density 6000 kg/m^3) of iron (atomic weight 56, valency 2) and metal P (atomic weight 24, valency 4). Faraday's constant = 96500 coulomb/mole. Volumetric material removal rate of the alloy is 50 mm^3/s at a current of 2000 A. The percentage of the metal P in the alloy is closest to

(*a*) 40 (*b*) 25

(*c*) 15 (*d*) 79

66. In a single pass rolling operation, a 20 mm thick plate with plate width of 100 mm, is reduced to 18 mm. The roller radius is 250 mm and rotational speed is 10 rpm. The average flow stress for the plate material is 300 MPa. The power required for the rolling operation in kW is closest to

(*a*) 15.2 (*b*) 18.2

(*c*) 30.4 (*d*) 45.6

67. In arc welding of a butt joint, the welding speed is to be selected such that highest cooling rate is achieved. Melting efficiency and heat transfer efficiency are 0.5 and 0.7, respectively. The area of the weld cross section is 5 mm^2 and the unit energy required to melt the metal is 10 J/mm^3. If the welding power is 2 kW, the welding speed in mm/s is closest to

(*a*) 4 (*b*) 14

(*c*) 24 (*d*) 34

68. In the deep drawing of cups, blanks show a tendency to wrinkle up around the periphery (flange). The most likely cause and remedy of the phenomenon are, respectively,

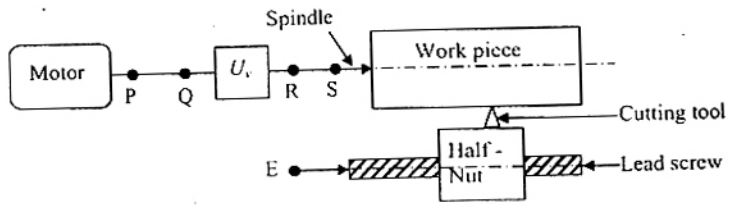
(*a*) Buckling due to circumferential compression; Increase blank holder pressure

(*b*) High blank holder pressure and high friction; Reduce blank holder pressure and apply lubricant

(*c*) High temperature causing increase in circumferential length; Apply coolant to blank

(*d*) Buckling due to circumferential compression; decrease blank holder pressure

69. The figure shows an incomplete schematic of a conventional lathe to be used for cutting threads with, different pitches. The speed gear box U_r is shown and the feed gear box U_s is to be placed. P, Q, R and S denote locations and have no other significance. Changes in U_r should NOT affect the pitch of the thread being cut and changes in U_s should NOT affect the cutting speed.



The correct connections and the correct placement of U_s are given by

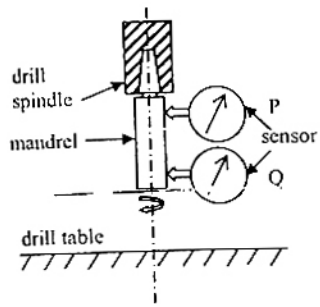
(*a*) Q and E are connected. U_s is placed between P and Q.

(*b*) S and E are connected. U_s is placed between R and S.

(*c*) Q and E are connected. U_s is placed between Q and E.

(*d*) S and E are connected. U_s is placed between S and E.

70. A displacement sensor (a dial indicator) measures the lateral displacement of a mandrel mounted on the taper hole inside a drill spindle. The mandrel axis is an extension of the drill spindle taper hole axis and the protruding portion of the mandrel surface is perfectly cylindrical. measurements are taken with the sensor placed at two positions P and Q as shown in the figure. The readings are recorded as R_x = maximum deflection minus minimum deflection, corresponding to sensor position at X, over one rotation.



If $R_P = R_Q > 0$, which one of the following would be consistent with the observation?

(a) The drill spindle rotational axis is coincident with the drill spindle taper hole axis

(b) The drill spindle rotational axis intersects the drill spindle taper hole axis at point P

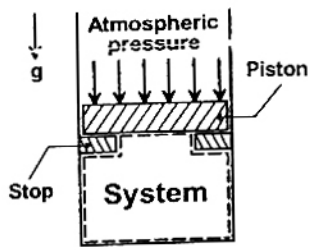
(c) The drill spindle rotational axis is parallel to the drill spindle taper hole axis

(d) The drill spindle rotational axis intersects the drill spindle taper hole axis at point Q

Common Data Questions

Common Data for Questions 71, 72 and 73:

In the figure shown, the system is a pure substance kept in a piston-cylinder arrangement. The system is initially a two-phase mixture containing 1 kg of liquid and 0.03 kg of vapour at a pressure of 100 kPa. Initially, the piston rests on a set of stops, as shown in the figure. A pressure of 200 kPa is required to exactly balance the weight of the piston and the outside atmospheric pressure. Heat transfer takes place into the system until its volume increases by 50%. Heat transfer to the system occurs in such a manner that the piston, when allowed to move, does so in a very slow (quasi-static / quasi-equilibrium) process. The thermal reservoir from which heat is transferred to the system has a temperature of 400°C. Average temperature of the system boundary can be taken as 175°C. The heat transfer to the system is 1 kJ, during which its entropy increases by 10 J/K.



Specific volume of liquid (v_f) and vapour (v_g) phases, as well as values of saturation temperatures, are given in the table below.

Pressure (kPa)	Saturation temperature, T_{sat} (°C)	v_f(m^3/kg)	v_g(m_3/kg)
100	100	0.001	0.1
200	200	0.0015	0.002

71. At the end of the process, which one of the following situations will be true?

(*a*) superheated vapour will be left in the system

(*b*) no vapour will be left in the system

(*c*) a liquid + vapour mixture will be left in the system

(*d*) the mixture will exist at a dry saturate vapour state

72. The work done by the system during the process is

(*a*) 0.1 kJ (*b*) 0.2 kJ

(*c*) 0.3 kJ (*d*) 0.4 kJ

73. The net entropy generation (considering the system and the thermal reservoir together) during the process is closest to

(*a*) 7.5 J/K (*b*) 7.7 J/K

(*c*) 8.5 J/K (*d*) 10 J/K

Common Data for Questions 74 and 75:

Consider the Linear Programme (LP)

Max $4x + 6y$

subject to

$3x + 2y \leq 6$

$2x + 3y \leq 6$

$x, y \geq 0$

74. After introducing slack variables s and t, the initial basic feasible solution is represented by the table below (basic variables are $s = 6$ and $t = 6$, and the objective function value is 0).

	−4	−6	0	0	0
s	3	2	1	0	6
t	2	3	0	1	6
	x	y	s	t	RHS

After some simplex iterations, the following table is obtained

	0	0	0	2	12
s	5/3	0	1	−1/3	2
y	2/3	1	0	1/3	2
	x	y	s	t	RHS

From this, one can conclude that

(*a*) the LP has a unique optimal solution

(*b*) the LP has an optimal solution that is not unique

(*c*) the LP is infeasible

(*d*) the LP is unbounded

75. The dual for the LP in Q 74 is

(*a*) Min 6u + 6v
subject to
$3u + 2v \geq 4$
$2u + 3v \geq 6$
$u, v \geq 0$

(*b*) Max 6u + 6v
subject to
$3u + 2v \leq 4$
$2u + 3v \leq 6$
$u, v \geq 0$

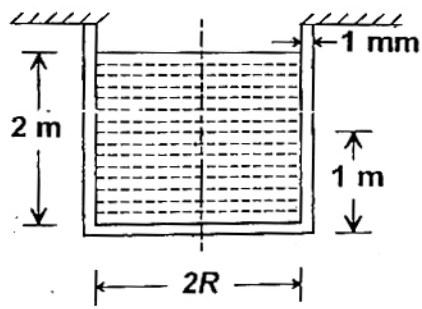
(*c*) Mix 4u + 6v
subject to
$3u + 2v \geq 6$
$2u + 3v \geq 6$
$u, v \geq 0$

(*d*) Min 4u + 6v
subject to
$3u + 2v \leq 6$
$2u + 3v \leq 6$
$u, v \geq 0$

Linked Answer Questions: Q.76 to Q.85 carry two marks each.

Statement for Linked Answer Questions 76 and 77:

A cylindrical container of radius R = 1 m, wall thickness 1 mm is filled with water up to a depth of 2 m and suspended along its upper rim. The density of water is 1000 kg/m^3 and acceleration due to gravity is 10 m/s^2. The self-weight of the cylinder is negligible. The formula for hoop stress in a thin-walled cylinder can be used at all points along the height of the cylindrical container.



76. The axial and circumferential stress (σ_a, σ_c) experienced by the cylinder wall at mid-depth (1 m as shown) are

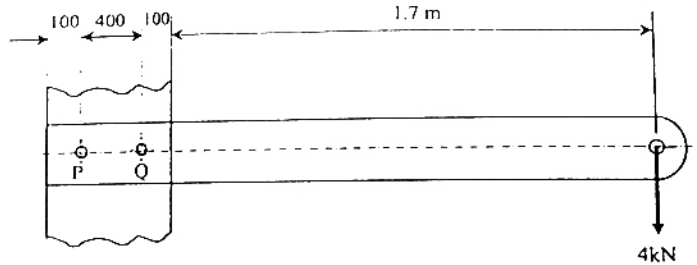
(*a*) (10, 10) MPa
(*b*) (5, 10) MPa
(*c*) (10, 5) MPa
(*d*) (5, 5) MPa

77. If the Young's modulus and Poisson's ratio of the container material are 100 GPa and 0.3, respectively, the axial strain in the cylinder wall at mid-depth is

(*a*) 2×10^{-6}
(*b*) 6×10^{-6}
(*c*) 7×10^{-6}
(*d*) 1.2×10^{-4}

Statement for Linked Answer Questions 78 and 79:

A steel bar of 10 × 50 mm is cantilevered with two M 12 bolts (P and Q) to support a static load of 4 kN as shown in the figure.



78. The primary and secondary shear loads on bolt P, respectively, are

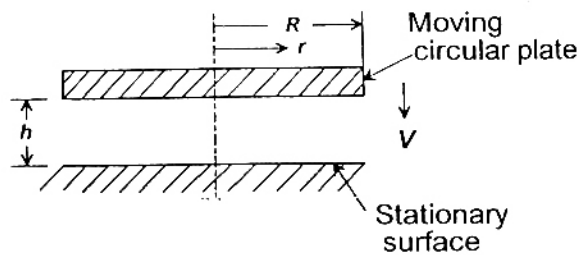
(*a*) 2 kN, 20 kN
(*b*) 20 kN, 2 kN
(*c*) 20 kN, 0 kN
(*d*) 0 kN, 20 kN

79. The resultant shear stress on bolt P is closest to

(*a*) 132 MPa
(*b*) 159 MPa
(*c*) 178 MPa
(*d*) 195 MPa

Statement for Linked Answer Questions 80 and 81:

The gap between a moving circular plate and a stationary surface is being continuously reduced, as the circular plate comes down at a uniform speed V towards the stationary bottom surface, as shown in the figure. In the process, the fluid contained between the two plates flows out radially. The fluid is assumed to be incompressible and inviscid.



80. The radial velocity v_r at any radius r, when the gap width is h, is

(*a*) $v_r = \frac{Vr}{2h}$
(*b*) $v_r = \frac{Vr}{h}$
(*c*) $v_r = \frac{2Vh}{r}$
(*d*) $v_r = \frac{Vh}{r}$

81. The radial component of the fluid acceleration at r = R is

(*a*) $\frac{3V^2R}{4h^2}$
(*b*) $\frac{V^2R}{4h^2}$
(*c*) $\frac{V^2R}{2h^2}$
(*d*) $\frac{V^2R}{4h^2}$

Statement for Linked Answer Questions 82 and 83:

Orthogonal turning is performed on a cylindrical workpiece with shear strength of 250 MPa. The following conditions are used: cutting velocity is 180 m/min, feed is 0.20 mm/rev, depth of cut is 3 mm, chip thickness ratio = 0.5. The orthogonal rake angle is 7°. Apply Merchant's theory for analysis.

82. The shear plane angle (in degrees) and the shear force respectively are

(*a*) 52 ; 320 N (*b*) 52 ; 400 N

(*c*) 28 ; 400 N (*d*) 28 ; 320 N

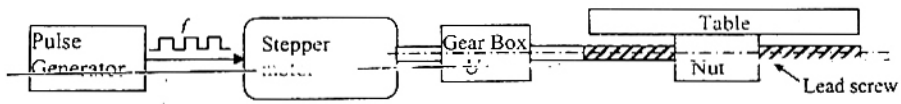
83. The cutting and frictional forces, respectively, are

(*a*) 568 N ; 387 N (*b*) 565 N ; 381 N

(*c*) 440 N ; 342 N (*d*) 480 N ; 356 N

Statement for Linked Answer Questions 84 and 85:

In the feed drive of a Point–to–Point open loop CNC drive, a stepper motor rotating at 200 steps/rev drives a table through a gear box and lead screw-nut mechanism (pitch = 4 mm, number of starts = 1). The gear ratio $= \left(\frac{\text{Output rotational speed}}{\text{Input rotational speed}}\right)$ is given by U = $\frac{1}{4}$. The stepper motor (driven by voltage pulses from a pulse generator) executes 1 step/pulse of the pulse generator. The frequency of the pulse train from the pulse generator is f = 10,000 pulses per minute.



84. The basic Length Unit (BLU), i.e., the table movement corresponding to 1 pulse of the pulse generator, is

(*a*) 0.5 microns (*b*) 5 microns

(*c*) 50 microns (*d*) 500 microns

85. A customer insists on a modification to change the BLU of the CNC drive to 10 microns without changing the table speed. The modification can be accomplished by

(*a*) changing U to $\frac{1}{2}$ and reducing f to $\frac{f}{2}$

(*b*) changing U to $\frac{1}{8}$ and increasing f to 2f

(*c*) changing U to $\frac{1}{2}$ and keeping f unchanged

(*d*) keeping U unchanged and increasing f to 2f

ANSWERS

1. (c)	**2.** (b)	**3.** (b)	**4.** (a)	**5.** (c)	**6.** (d)	**7.** (d)	**8.** (d)	**9.** (b)	**10.** (d)
11. (b)	**12.** (d)	**13.** (b)	**14.** (*)	**15.** (d)	**16.** (b)	**17.** (c)	**18.** (a)	**19.** (*)	**20.** (c)
21. (a)	**22.** (b)	**23.** (d)	**24.** (d)	**25.** (*)	**26.** (d)	**27.** (b)	**28.** (c)	**29.** (a)	**30.** (*)
31. (d)	**32.** (b)	**33.** (a)	**34.** (b)	**35.** (b)	**36.** (c)	**37.** (*)	**38.** (*)	**39.** (d)	**40.** (*)
41. (b)	**42.** (c)	**43.** (a)	**44.** (*)	**45.** (*)	**46.** (b)	**47.** (a)	**48.** (c)	**49.** (*)	**50.** (d)
51. (d)	**52.** (a)	**53.** (b)	**54.** (b)	**55.** (*)	**56.** (d)	**57.** (c)	**58.** (d)	**59.** (*)	**60.** (c)
61. (c)	**62.** (d)	**63.** (b)	**64.** (*)	**65.** (*)	**66.** (*)	**67.** (b)	**68.** (*)	**69.** (d)	**70.** (c)
71. (*)	**72.** (*)	**73.** (*)	**74.** (b)	**75.** (a)	**76.** (b)	**77.** (a)	**78.** (a)	**79.** (b)	**80.** (*)
81. (*)	**82.** (d)	**83.** (*)	**84.** (b)	**85.** (a)					

EXPLANATIONS

1. Taylor series expansion of f(x) about a is given by

$$f(x) = f(a) + \frac{(x-a)}{1!} f'(a) + \frac{(x-a)^2}{2!} f''(a) + \text{- - - - -}$$

Coefficient of $(x-a)^4$ is $\frac{f''''(a)}{4!}$

Now $f(x) = e^x$

$\Rightarrow$ $f''''(x) = e^x$

$\Rightarrow$ $f''''(a) = e^a$

Hence for a = 2, $\frac{f''''(a)}{4!} = \frac{e^2}{4!}$

2. $\ddot{x} + 3x = 0$

$\Rightarrow$ $(D^2 + 3)\, x = 0$

$$\text{P.I.} = \left(\frac{1}{D^2+3}\right)(0) = 0$$

Now C.F. is given by, $C_1 e^{m_1 t} + C_2 e^{m_2 t}$

$\therefore$ $m^2 + 3 = 0$

$\Rightarrow$ $m = \pm i\sqrt{3}$

Hence the solution is C.F. + P.I.

i.e. $C_1 e^{i\sqrt{3}t} + C_2 e^{-i\sqrt{3}t}$

But $x(0) = 1 \quad \Rightarrow C_1 + C_2 = 1$

and $x(0) = 0,\ x = i\sqrt{3}\, C_1 e^{i\sqrt{3}t} - i\sqrt{3}\, C_2 e^{-i\sqrt{3}t}$

$\Rightarrow$ $x(0) = 0 \quad \Rightarrow C_1 = C_2 = \frac{1}{2}$

Q. No. 1 – 20 Carry One Mark Each

1. For a matrix [M]= $\begin{bmatrix} \frac{3}{5} & \frac{4}{5} \\ x & \frac{3}{5} \end{bmatrix}$, the transpose of the matrix is equal to the inverse of the matrix $[M]^T = [M]^{-1}$. The value of x is given by

(A) $-\frac{4}{5}$ (B) $-\frac{3}{5}$ (C) $\frac{3}{5}$ (D) $\frac{4}{5}$

2. The divergence of the vector field $3xz\hat{i} + 2xy\hat{j} - yz^2\hat{k}$ at a point (1,1,1) is equal to

(A) 7 (B) 4 (C) 3 (D) 0

3. The inverse Laplace transform of $\frac{1}{(s^2 + s)}$ is

(A) $1 + e^t$ (B) $1 - e^t$ (C) $1 - e^{-t}$ (D) $1 + e^{-t}$

4. If three coins are tossed simultaneously, the probability of getting at least one head

(A) 1/8 (B) 3/8 (C) 1/2 (D) 7/8

5. If a closed system is undergoing an irreversible process, the entropy of the system

(A) Must increase
(B) Always remains constant
(C) Must decrease
(D) Can increase, decrease or remain constant

6. A coolant fluid at 30°C flows over a heated flat plate maintained at a constant temperature of 100°C. The boundary layer temperature distribution at a given location on the plate may be approximated as $T = 30 + 70\exp(-y)$ where y (in m) is the distance normal to the plate and T is in °C. If thermal conductivity of the fluid is 1.0W/mK, the local convective heat transfer coefficient (in W/m^2K) at that location will be

(A) 0.2 (B) 1 (C) 5 (D) 10

7. A frictionless piston-cylinder device contains a gas initially at 0.8MPa and 0.015 m^3. It expands quasi-statically at constant temperature to a final volume of 0.030 m^3. The work output (in kJ) during this process will be

(A) 8.32 (B) 12.00 (C) 554.67 (D) 8320.00

8. In an ideal vapour compression refrigeration cycle, the specific enthalpy of refrigerant (in kJ/kg) at the following states is given as:

Inlet of condenser: 283

Exit of condenser: 116

Exit of evaporator: 232

The COP of this cycle is

(A) 2.27 (B) 2.75 (C) 3.27 (D) 3.75

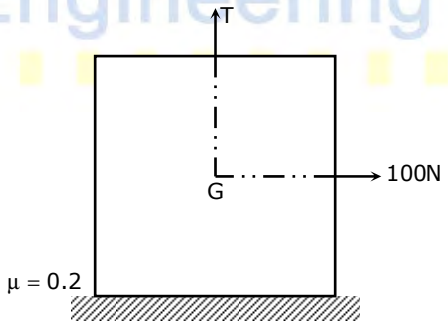
9. A compressor undergoes a reversible, steady flow process. The gas at inlet and outlet of the compressor is designated as state 1 and state 2 respectively. Potential and kinetic energy changes are to be ignored. The following notations are used:

v= specific volume and P=pressure of the gas.

The specific work required to be supplied to the compressor for this gas compression process is

(A) $\int_1^2 Pdv$ (B) $\int_1^2 vdP$ (C) $v_1(P_2 - P_1)$ (D) $-P_2(v_1 - v_2)$

10. A block weighing 981N is resting on a horizontal surface. The coefficient of friction between the block and the horizontal surface is μ = 0.2A vertical cable attached to the block provides partial support as shown. A man can pull horizontally with a force of 100N. What will be the tension, T (in N) in the cable if the man is just able to move the block to the right?

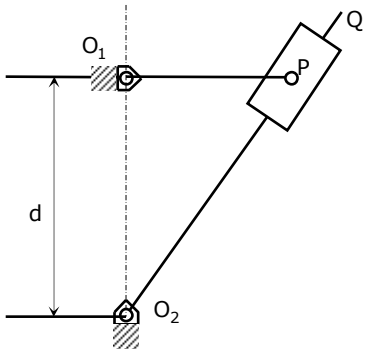


(A) 176.2 (B) 196.0 (C) 481.0 (D) 981.0

11. If the principal stresses in a plane stress problem, are $\sigma_1 = 100MPa$, $\sigma_2 = 40MPa$, the magnitude of the maximum shear stress (in MPa) will be

(A) 60 (B) 50 (C) 30 (D) 20

12. A simple quick return mechanism is shown in the figure. The forward to return ratio of the quick return mechanism is 2:1. If the radius of the crank O_1P is 125 mm, then the distance 'd' (in mm) between the crank centre to lever pivot centre point should be



(A) 144.3 (B) 216.5 (C) 240.0 (D) 250.0

13. The rotor shaft of a large electric motor supported between short bearings at both deflection of 1.8mm in the middle of the rotor. Assuming the rotor to be perfectly balanced and supported at knife edges at both the ends, the likely critical speed (in rpm) of the shaft is

(A) 350 (B) 705 (C) 2810 (D) 4430

14. A solid circular shaft of diameter d is subjected to a combined bending moment M and torque, T. The material property to be used for designing the shaft using the relation $\frac{16}{\pi d^3}\sqrt{M^2+T^2}$ is

(A) ultimate tensile strength (S_u) (B) tensile yield strength (S_y)

(C) torsional yield strength (S_{sy}) (D) endurance strength (S_e)

15. The effective number of lattice points in the unit cell of simple cubic, body centered cubic, and face centered cubic space lattices, respectively, are

(A) 1,2,2 (B) 1,2,4 (C) 2,3,4 (D) 2,4,4

16. Friction at the tool-chip interface can be reduced by

(A) decreasing the rake angle (B) increasing the depth of cut

(C) decreasing the cutting speed (D) increasing the cutting speed

17. Two streams of liquid metal, which are not hot enough to fuse properly, result into a casting defect known as

(A) cold shut (B) swell (C) sand wash (D) scab

18. The expected time (t_e) of a PERT activity in terms of optimistic time (t_0), pessimistic time (t_p) and most likely time (t_l) is given by

(A) $t_e = \frac{t_o + 4t_l + t_p}{6}$ (B) $t_e = \frac{t_o + 4t_p + t_l}{6}$

(C) $t_e = \frac{t_o + 4t_l + t_p}{3}$ (D) $t_e = \frac{t_o + 4t_l + t_l}{3}$

19. Which of the following is the correct data structure for solid models?
(A) solid part → faces → edges → vertices
(B) solid part → edges → faces → vertices
(C) vertices → edges → faces → solid parts
(D) vertices → faces → edges → solid parts

20. Which of the following forecasting methods takes a fraction of forecast error into account for the next period forecast?
(A) simple average method (B) moving average method
(C) weighted moving average method (D) exponential smoothening method

Q. No. 21 – 56 Carry Two Marks Each

21. An analytic function of a complex variable z = x + iy is expressed as $f(z) = u(x,y) + iv(x,y)$ where $i = \sqrt{-1}$. If u = xy, the expression for v should be

(A) $\frac{(x+y)^2}{2} + k$ (B) $\frac{x^2 - y^2}{2} + k$ (C) $\frac{y^2 - x^2}{2} + k$ (D) $\frac{(x-y)^2}{2} + k$

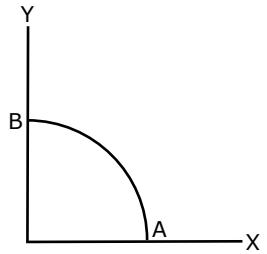
22. The solution of $x\frac{dy}{dx} + y = x^4$ with the condition $y(1) = \frac{6}{5}$ is

(A) $y = \frac{x^4}{5} + \frac{1}{x}$ (B) $y = \frac{4x^4}{5} + \frac{4}{5x}$ (C) $y = \frac{x^4}{5} + 1$ (D) $y = \frac{x^5}{5} + 1$

23. A path AB in the form of one quarter of a circle of unit radius is shown in the figure. Integration of $(x+y)^2$ on path AB traversed in a counter-clockwise sense is

(A) $\frac{\pi}{2} - 1$ (B) $\frac{\pi}{2} + 1$

(C) $\frac{\pi}{2}$ (D) 1



24. The distance between the origin and the point nearest to it on the surface $z^2 = 1 + xy$ is

(A) 1 (B) $\frac{\sqrt{3}}{2}$ (C) $\sqrt{3}$ (D) 2

25. The area enclosed between the curves $y^2 = 4x$ and $x^2 = 4y$ is

(A) $\frac{16}{3}$ (B) 8 (C) $\frac{32}{3}$ (D) 16

26. The standard deviation of a uniformly distributed random variable between 0 and 1 is

(A) $\frac{1}{\sqrt{12}}$ (B) $\frac{1}{\sqrt{3}}$ (C) $\frac{5}{\sqrt{12}}$ (D) $\frac{7}{\sqrt{12}}$

27. Consider steady, incompressible and irrotational flow through a reducer in a horizontal pipe where the diameter is reduced from 20cm to 10cm. The pressure in the 20cm pipe just upstream of the reducer is 150kPa. The fluid has a vapour pressure of 50kPa and a specific weight of 5 kN/m^3. Neglecting frictional effects, the maximum discharge (in m^3/s) that can pass through the reducer without causing cavitation is

(A) 0.05 (8) 0.16 (C) 0.27 (D) 0.38

28. In a parallel flow heat exchanger operating under steady state, the heat capacity rates (product of specific heat at constant pressure and mass flow rate) of the hot and cold fluid are equal. The hot fluid, flowing at 1kg/s with C_p = 4kJ/kgK, enters the heat exchanger at 102°C while the cold fluid has an inlet temperature of 15°C. The overall heat transfer coefficient for the heat exchanger is estimated to be 1kW/m^2K and the corresponding heat transfer surface area is 5m^2. Neglect heat transfer between the heat exchanger and the ambient. The heat exchanger is characterized by the following relation:

$2\varepsilon = 1 - \exp(-2\text{NTU})$.

The exit temperature (in °C) for the cold fluid is

(A) 45 (B)55 (C) 65 (D) 75

29. In an air-standard Otto cycle, the compression ratio is 10. The condition at the beginning of the compression process is 100kPa and 27°C. Heat added at constant volume is 1500kJ/kg, while 700kJ/kg of heat is rejected during the other constant volume process in the cycle. Specific gas constant for air=0.287 kJ/kgK. The mean effective pressure (in kPa) of the cycle is

(A) 103 (B) 310 (C) 515 (D) 1032

30. An irreversible heat engine extracts heat from a high temperature source at a rate of 100kW and rejects heat to a sink at a rate of 50kW. The entire work output of the heat engine is used to drive a reversible heat pump operating between a set of independent isothermal heat reservoirs at 17°C and 75°C. The rate (in kW) at which the heat pump delivers heat to its high temperature sink is

(A) 50 (B) 250 (C) 300 (D) 360

31. You are asked to evaluate assorted fluid flows for their suitability in a given laboratory application. The following three flow choices, expressed in terms of the two-dimensional velocity fields in the xy-plane, are made available.

P. $u = 2y, \quad v = -3x$

Q. $u = 3xy, v = 0$

R. $u = -2x, v = 2y$

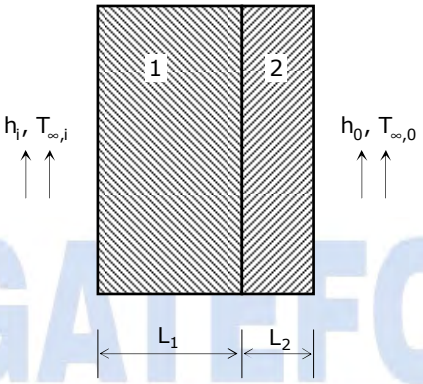
Which flow(s) should be recommended when the application requires the flow to be incompressible and irrotational?

(A) P and R (B) Q (C) Q and R (D) R

32. Water at 25°C is flowing through a 1.0km long G.I pipe of 200mm diameter at the rate of $0.07m^3/s$. If value of Darcy friction factor for this pipe is 0.02 and density of water is $1000kg/m^3$, the pumping power (in kW) required to maintain the flow is

(A) 1.8 (B) 17.4 (C) 20.5 (D) 41.0

33. Consider steady-state heat conduction across the thickness in a plane composite wall (as shown in the figure) exposed to convection conditions on both sides.



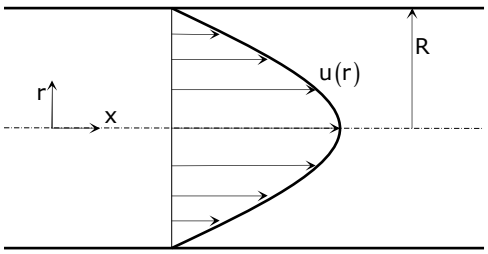
Given:

$h_i = 20W/m^2K$; $h_0 = 50W/m^2K$; $T_{\infty,i} = 20^0C$; $T_{\infty,0} = -2^0C$; $k_1 = 20W/mK$; $k_2 = 50W/mK$; $L_1 = 0.30m$ and $L_2 = 0.15m$.

Assuming negligible contact resistance between the wall surfaces, the interface temperature, T (in °C), of the two walls will be

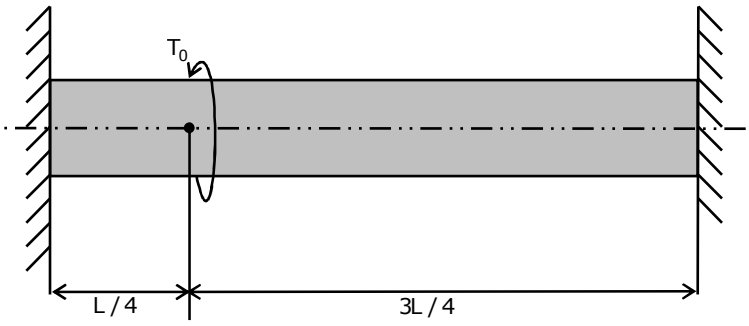
(A) -0.50 (B) 2.75 (C) 3.75 (D) 4.50

34. The velocity profile of a fully developed laminar flow in a straight circular pipe, as shown in the figure, is given by the expression $u(r) = -\frac{R^2}{4\mu}\left(\frac{dp}{dx}\right)\left(1-\frac{r^2}{R^2}\right)$ where $\frac{dp}{dx}$ is a constant. The average velocity of fluid in the pipe is



(A) $-\frac{R^2}{8\mu}\left(\frac{dp}{dx}\right)$ (B) $-\frac{R^2}{4\mu}\left(\frac{dp}{dx}\right)$ (C) $-\frac{R^2}{2\mu}\left(\frac{dp}{dx}\right)$ (D) $-\frac{R^2}{\mu}\left(\frac{dp}{dx}\right)$

35. A solid shaft of diameter, d and length L is fixed at both the ends. A torque, T_0 is applied at a distance, L/4 from the left end as shown in the figure given below



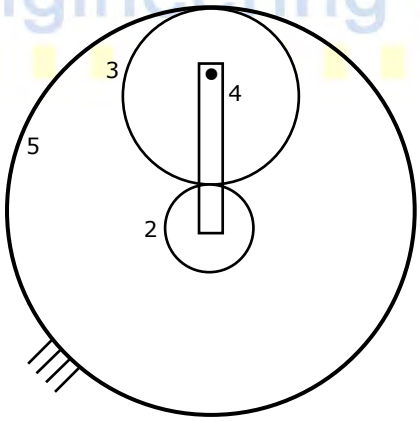
The maximum shear stress in the shaft is

(A) $\frac{16T_0}{\pi d^3}$ (B) $\frac{12T_0}{\pi d^3}$ (C) $\frac{8T_0}{\pi d^3}$ (D) $\frac{4T_0}{\pi d^3}$

36. An epicyclic gear train is shown schematically in the adjacent figure

The sun gear 2 on the input shaft is a 20 teeth external gear. The planet gear 3 is a 40 teeth external gear. The ring gear 5 is a 100 teeth internal gear. The ring gear 5 is fixed and the gear 2 is rotating at 50 rpm ccw (ccw=counter-clockwise and cw=clockwise)

The arm 4 attached to the output shaft will rotate at



(A) 10 rpm ccw (B) 10 rpm cw (C) 12 rpm cw (D) 12 rpm ccw

37. A forged steel link with uniform diameter of 30mm at the centre is subjected to an axial force that varies from 40kN in compression to 160kN in tension. The tensile (S_u), yield (S_y) and corrected endurance (S_e) strengths of the steel material are 600MPa, 420MPa and 240MPa respectively. The factor of safety against fatigue endurance as per Soderberg's criterion is

(A) 1.26 (B) 1.37 (C) 1.45 (D) 2.00

38. An automotive engine weighing 240kg is supported on four springs with linear characteristics. Each of the front two springs have a stiffness of 16MN/m while the stiffness of each rear spring is 32MN/m. The engine speed (in rpm), at which resonance is likely to occur, is

(A) 6040 (B) 3020 (C) 1424 (D) 955

39. A vehicle suspension system consists of a spring and a damper. The stiffness of the spring is 3.6kN/m and the damping constant of the damper is 400Ns/m. If the mass is 50kg, then the damping factor (d) and damped natural frequency (f_n), respectively, are

(A) 0.471 and 1.19Hz (B) 0.471 and 7.48Hz

(C) 0.666 and 1.35Hz (D) 0.666 and 8.50Hz

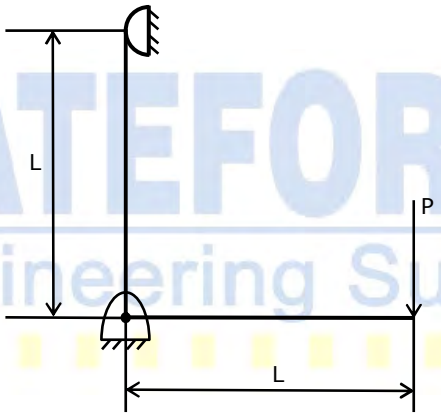
40. A frame of two arms of equal length L is shown in the adjacent figure. The flexural rigidity of each arm of the frame is EI. The vertical deflection at the point of application of load P is

(A) $\frac{PL^3}{3EI}$

(B) $\frac{2PL^3}{3EI}$

(C) $\frac{PL^3}{EI}$

(D) $\frac{4PL^3}{3EI}$



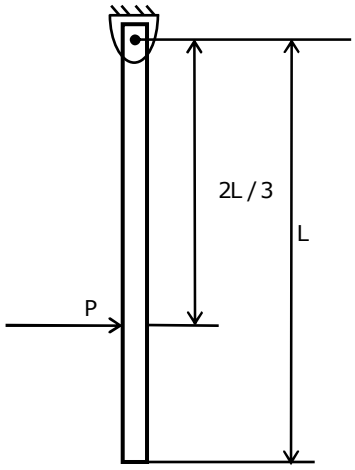
41. A uniform rigid rod of mass M and length L is hinged at one end as shown in the adjacent figure. A force P is applied at a distance of 2L/3 from the hinge so that the rod swings to the right. The reaction at the hinge is

(A) -P

(B) 0

(C) P/3

(D) 2P/3



42. Match the approaches given below to perform stated kinematics / dynamics analysis of machine.

Analysis	Approach
P. Continuous relative rotation	1. D' Alembert's principle
Q. Velocity and acceleration	2. Grubler's criterion
R. Mobility	3. Grashoff's law
S. Dynamic-static analysis	4. Kennedy's theorem

(A) P-1,Q-2,R-3,S-4 (B) P-3,Q-4,R-2,S-1

(C) P-2,Q-3,R-4,S-1 (D) P-4,Q-2,R-1,S-3

43. A company uses 2555 units of an item annually. Delivery lead time is 8 days. The recorder point (in number of units) to achieve optimum inventory is

(A) 7 (B) 8 (C) 56 (D) 60

44. Consider the following Linear Programming Problem (LPP):

Maximize $z = 3x_1 + 2x_2$

Subject to $x_1 \leq 4$

$x_2 \leq 6$

$3x_1 + 2x_2 \leq 18$

$x_1 \geq 0, x_2 \geq 0$

(A) The LPP has a unique optimal solution

(B) The LPP is infeasible

(C) The LPP is unbounded

(D) The LPP has multiple optimal solutions

45. Six jobs arrived in a sequence as given below:

Jobs	Processing Time (days)
I	4
II	9
III	5
IV	10
V	6
VI	8

Average flow time (in days) for the above jobs using Shortest Processing Time rule is

(A) 20.83 (B) 23.16 (C) 125.00 (D) 139.00

46. Minimum shear strain in orthogonal turning with a cutting tool of zero rake angle is

(A) 0.0 (B) 0.5 (C) 1.0 (D) 2.0

47. Electrochemical machining is performed to remove material from an iron surface of 20mm×20mm under the following conditions:

Inter electrode gap	= 0.2mm
Supply voltage (DC)	= 12V
Specific resistance of electrolyte	= 2Ωcm
Atomic weight of Iron	= 55.85
Valency of Iron	= 2
Faraday's constant	= 96540 Coulombs

The material removal rate (in g/s) is

(A) 0.3471 (B) 3.471 (C) 34.71 (D) 347.1

48. Match the following

NC Code	Definition
P. M05	1. Absolute coordinate system
Q. G01	2. Dwell
R. G04	3. Spindle stop
S. G90	4. Linear interpolation

(A) P-2,Q-3,R-4,S-1 (B) P-3,Q-4,R-1,S-2

(C) P-3,Q-4,R-2,S-1 (D) P-4,Q-3,R-2,S-1

49. What are the upper and lower limits of the shaft represented by 60 f_8?

Use the following data:

Diameter 60 lies in the diameter step of 50-80mm

Fundamental tolerance unit, i, in μm=$0.45D^{1/3}+0.001D$, where D is the representative size in mm;

Tolerance value for IT8=25i. Fundamental deviation for 'f' shaft = $-5.5D^{0.41}$

(A) Lower limit = 59.924mm, Upper Limit = 59.970mm

(B) Lower limit = 59.954mm, Upper Limit = 60.000mm

(C) Lower limit = 59.970mm, Upper Limit = 60.016mm

(D) Lower limit = 60.000mm, Upper Limit = 60.046mm

50. Match the items in Column I and Column II.

Column I	Column II
P. Metallic Chills	1. Support for the core
Q. Metallic Chaplets	2. Reservoir of the molten metal
R. Riser	3. Control cooling of critical sections
S. Exothermic Padding	4. Progressive solidification

(A) P-1,Q-3,R-2,S-4 (B) P-1,Q-4,R-2,S-3

(C) P-3,Q-4,R-2,S-1 (D) P-4,Q-1,R-2,S-3

Common Data Questions: 51 & 52

The inlet and the outlet conditions of stream for an adiabatic steam turbine are as indicated in the notations are as usually followed

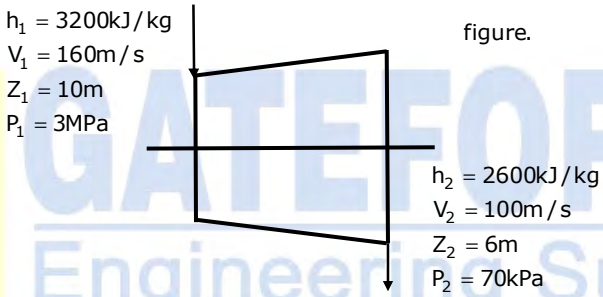


figure.

51. If mass flow rate of steam through the turbine is 20kg/s, the power output of the turbine (in MW) is

(A) 12.157 (B) 12.941 (C) 168.001 (D) 168.785

52. Assume the above turbine to be part of a simple Rankine cycle. The density of water at the inlet to the pump is 1000kg/m^3. Ignoring kinetic and potential energy effects, the specific work (in kJ/kg) supplied to the pump is

(A) 0.293 (B) 0.351 (C) 2.930 (D) 3.510

Common Data Questions: 53 & 54

Radiative heat transfer is intended between the inner surfaces of two very large isothermal parallel metal plates. While the upper plate (designated as plate 1) is a black surface and is the warmer one being maintained at 727ºC, the lower plate (plate 2) is a diffuse and gray surface with an emissivity of 0.7 and is kept at 227ºC. Assume that the surfaces are sufficiently large to form a two-surface enclosure and steady state conditions to exist. Stefan Boltzmann constant is given as $5.67\times10^{-8}W/m^2K^4$

53. The irradiation (in kW/m^2) for the upper plate (plate 1) is

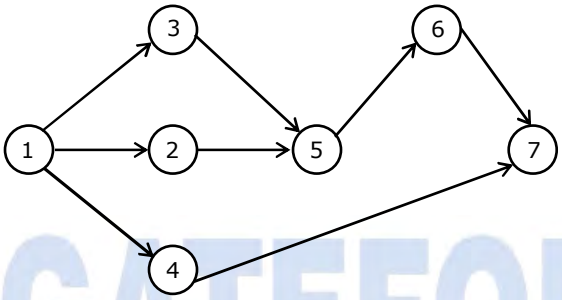
(A) 2.5 (B) 3.6 (C) 17.0 (D) 19.5

54. If plate 1 is also a diffuse and gray surface with an emissivity value of 0.8, the net radiation heat exchange (in kW/m^2) between plate 1 and plate 2 is

(A) 17.0 (B) 19.0 (C) 23.0 (D) 31.7

Common Data Questions: 55 & 56

Consider the following PERT network:



The optimistic time, most likely time and pessimistic time of all the activities are given in the table below

Activity	Optimistic time (days)	Most likely time (days)	Pessimistic time (days)
1-2	1	2	3
1-3	5	6	7
1-4	3	5	7
2-5	5	7	9
3-5	2	4	6
5-6	4	5	6
4-7	4	6	8
6-7	2	3	4

55. The critical path duration of the network (in days) is

(A) 11 (B) 14 (C) 17 (D) 18

56. The standard deviation of the critical path is

(A) 0.33 (B) 0.55 (C) 0.77 (D) 1.66

Linked Answer Questions: Q.57 to Q.60 Carry Two Marks Each

Statement for Linked Answer Questions: 57 & 58

In a machining experiment, tool life was found to vary with the cutting speed in the following manner:

Cutting speed (m/min)	Tool life (minutes)
60	81
90	36

57. The exponent (n) and constant (k) of the Taylor's tool life equation are

(A) $n = 0.5$ and $k = 540$ (B) $n = 1$ and $k = 4860$

(C) $n = -1$ and $k = 0.74$ (D) $n = -0.5$ and $k = 1.155$

58. What is the percentage increase in tool life when the cutting speed is halved?

(A) 50% (B) 200% (C) 300% (D) 400%

Statement for Linked Answer Questions: 59 & 60

A 20º full depth involute spur pinion of 4mm module and 21 teeth is to transmit 15kW at 960rpm. Its face width is 25mm.

59. The tangential force transmitted (in N) is

(A) 3552 (B) 2611 (C) 1776 (D) 1305

60. Given that the tooth geometry factor is 0.32 and the combined effect of dynamic load and allied factors intensifying the stress is 1.5; the minimum allowable stress (in MPa) for the gear material is

(A) 242.0 (B) 166.5 (C) 121.0 (D) 74.0