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Engineering Examination

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MECHANICAL ENGINEERING
SET - C

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1. A mass of 1 kg of air at 27°C and 0.98 atm is taken through a diesel cycle. If the compression ratio of the engine is 16, calculate the temperature of the air after compression? (For calculation, take the ratio of specific heats of air as 1.5)

(a) 1200 deg C (b) 1473 deg C (c) 927 deg C (d) 768 deg C

1. ***Ans. (c)***

$$m = 1 \text{ kg}, T = 300 \text{ K},$$

$$P_{atm} = 0.98 \text{ atm}, r = 16$$

$$\frac{T_2}{T_1} = \left(\frac{V_1}{V_2}\right)^{\gamma-1}$$

$$\gamma = 1.5$$

$$\frac{T_2}{300} = (16)^{0.5}$$

$$T_2 = 300 \times (16)^{0.5}$$

$$T_2 = 927°$$

2. An aircraft is in its take off roll at sea level with ambient temperature of 18°C. What is the approximate speed of the aircraft if the temperature measured by a probe at the exit of the engine diffuser is 36°C? (Assuming air stagnation at diffuser outlet and C_p of air as 1.0 kJ/kgK)

(a) 12 m/s (b) 3 m/s (c) 6 m/s (d) 18 m/s

2. ***Ans. (*)***

Enthalpy loss will convert into kinetic energy of Jet

$$V_1 = \sqrt{2(h_1 - h_2)}$$

$$= \sqrt{2 \times C_P (T_1 - T_2)}$$

$$= \sqrt{2 \times 1 \times 10^3 \times (36 - 18)}$$

$$= \sqrt{2 \times 18 \times 10^3}$$

$$= \sqrt{36 \times 1000}$$

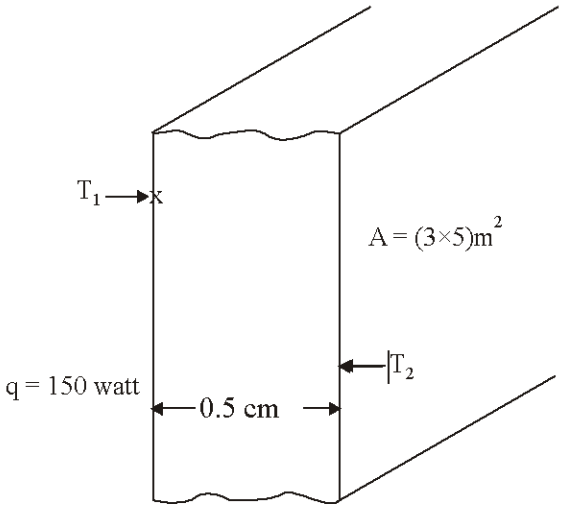
$$= 60\sqrt{10} \text{ m/s}$$

3. The external surface of a wall of 3 m height, 5 m width and 0.5 m thickness is at a temperature of 2°C. If a heat loss of 150 W from the room is measured across the wall, find the inner wall temperature? The thermal conductivity of wall material can be taken as 1W/mK

(a) 280 K (b) 285 K (c) 268 K (d) 282 K

3. ***Ans. (a)***

3m height, 5m width, and 0.5 thick at temp 2°C,



$$q = 150 \text{ W}$$

$$q = kA\frac{dT}{dx}$$

$$150 = 1 \times 15 \times \frac{dT}{0.5}$$

$$150 = 30\ dT$$

$$dT = \frac{150}{30}$$

$$T_1 - T_0 = 5$$

$$T_i = 7°C = 280 \text{ K}$$

4. The typical range of Prandtl number for water is

(a) 0.004–0.300 (b) 1.7–13.7 (c) 50–500 (d) 2000–1000

4. ***Ans. (b)***

Fluid	Pr Range
Liquid Metals	0.004 – 0.03
Gases	0.7 – 1
Water	1.7 – 13.7
Liquid Organic Fluid	5 – 50
Oils	50 – 100,000
Glycerin	2000 – 100,000

5. Analogy between momentum and heat transfer is known as

(a) Stanton-Prandtl analogy (b) Grassoff-Meyer analogy

(c) Chilton-Colburn analogy (d) None of the above

5. ***Ans. (c)***

Heat and momentum analogy

Momentum transfer

$$t = \mu \frac{du}{dz}$$

Heat transfer $q = k\frac{dT}{dz}$

In Reynold analogy Pr = 1,

When Pr ≠ 1, Poor results obtain.

This analogy was modified Chilton and Colburn analogy.

6. The laws of adhesive wear, commonly referred to as Archard's law can be expressed as _____.

(If 'Q' is the total volume of wear debris produced, 'W' is the normal load, 'L' is the sliding distance, 'H' is the hardness of the softest contacting surfaces being worn away, and 'k' is a non-dimensional wear coefficient dependent on the materials in contact and their exact degree of cleanliness)

(a) Q = kWL/H (b) Q = kW/LH (c) Q = kHW/L (d) Q = k/LWH

6. ***Ans. (a)***

Archard's Law

$$Q = \frac{kWL}{H}$$

7. In a four-bar linkage if 'S' is the length of the shortest link, 'L' is the length of longest link and 'P' and 'Q' are length of other links, then the criteria for getting a triple rocker mechanism in which no links will fully rotate is :

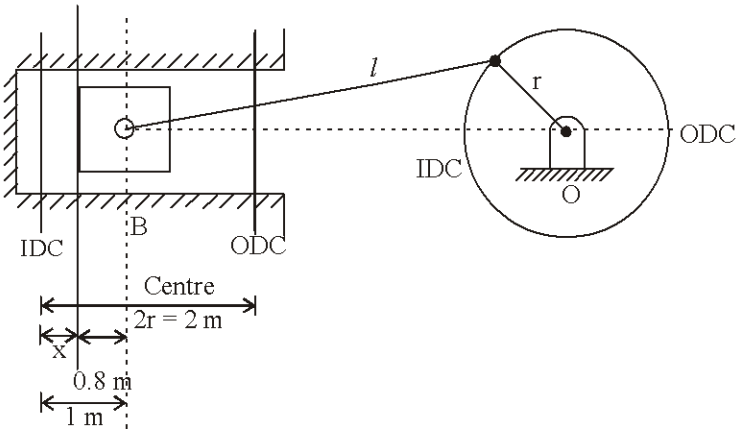
(a) S + Q > P + L (b) S + L > P + Q (c) S + L = P + Q (d) S + L > P + Q

7. ***Ans. (d)***

8. The piston of an engine moves with simple harmonic motion. The crank rotates at 120 r.p.m. with a stroke of 2 meters. The velocity of the piston, when it is at a distance of 0.8 metre from the center is :

(a) 4.8 π (b) 2.4 π (c) 1.2 π (d) 0.6 π

8. ***Ans. (b)***



$N = 120$ rpm

$\omega = 4\pi$ rad/s

Stroke $= 2m = 2r$

$r = 1m$ = Crank radius

$$n = \frac{L}{r} = \text{Large}$$

$$x = r\left[(1-\cos\theta)+\left(n-\sqrt{n^2-\sin\theta}\right)\right]$$

n^2 = very large

$0.2 = 1[1 - \cos\theta]$

$$\cos\theta = 1 - 0.2 = \frac{4}{5}$$

$$\sin\theta = \sqrt{1-\frac{16}{25}} = \frac{3}{5}$$

$$V = rw\left[\sin\theta+\frac{\sin 2\theta}{2n}\right] \quad n=\text{large}$$

$$V = r\omega\sin\theta = 1 \times 4\pi \times \frac{3}{5} = \frac{12\pi}{5} = 2.4\ \pi$$

9. If a block slides outward on a link at a uniform rate of 30 m/s, while the link is rotating at a constant angular velocity of 50 rad/s counter clockwise, the Coriolis component of acceleration is _____ m/s².

(a) 1000 (b) 1500 (c) 3000 (d) 4500

9. ***Ans. (c)***

Coriolies acceleration

$= 2V\omega$

$= 2 \times 30 \times 50$

$= 3000\ m/s^2$

10. In a screw jack of lead angle α, the effort required to lift the load W is given by ____ (ϕ = Friction Angle)

(a) $P = W \tan(\alpha - \phi)$ (b) $P = W \tan(\alpha + \phi)$

(c) $P = W \cos(\alpha - \phi)$ (d) $P = W \cos(\alpha + \phi)$

10. ***Ans. (b)***

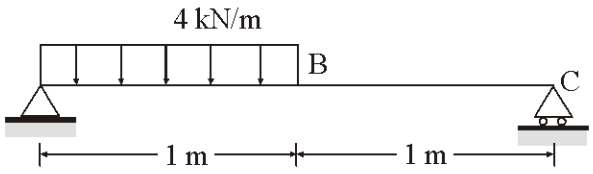
$P = W\tan(\alpha + \phi)$

11. The ratio of maximum shear stress to average shear stress in a beam of rectangular section is

(a) 5.1 (b) 2/3 (c) 3/2 (d) 1.0

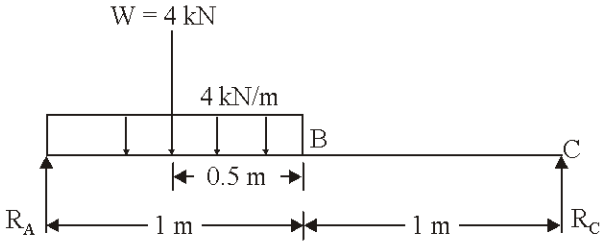
11. ***Ans. (c)***

12. A massless beam has a loading pattern shown in figure. Find the bending moment at mid span.



(a) 1 kN-m (b) 3 kN-m (c) 2 kN-m (d) 0.0 kN-m

12. ***Ans. (a)***



$$R_A = \frac{4 \times 1.5}{2} = 3kN$$

$M_B = R_A \times 1 - W \times 0.5$

$= 3 \times 1 - 4 \times 0.5 = 1$ kN-m

13. Steel machine element at the critical section is in biaxial stress state with two principal stress being 300 N/mm² and 300 N/mm² (equal magnitude). Find the von Mises stress (in N/mm²) in the member

(a) 212.1 (b) 600 (c) 424.2 (d) 300

13. ***Ans. (d)***

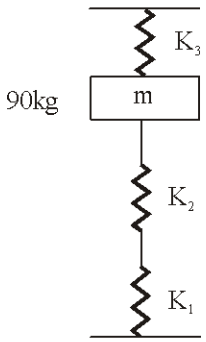
$$\sigma = 300 \text{ MPa} = \sigma_1 = \sigma_2$$

By using M.D.E.T.

$$\sigma_{per} = \sqrt{\sigma_1^2 + \sigma_2^2 - \sigma_1\sigma_2}$$

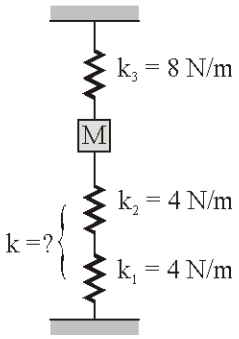
$$= 300 \text{ MPa}$$

14. A machine component of 90 kg mass needs to be held in position using three springs as shown below. The spring constants K_1, K_2 and K_3 are 4, 4 and 8 N/m respectively. Find the natural frequency of the system in rad/sec.



(a) 0.33 (b) 0.42 (c) 0.13 (d) 3.0

14. ***Ans. (a)***



Same as questions

$$\frac{1}{K} = \frac{1}{K_1} + \frac{1}{K_2} = \frac{1}{4} + \frac{1}{4} = \frac{2}{4} = \frac{1}{2}$$

$$K = 2 \text{ N/m}$$

Total $K_{er} = (K + K_3) = 10 \text{ N/m}$

$$\omega_n = \sqrt{\frac{K_{eq}}{m}} = \sqrt{\frac{10}{90}} = \sqrt{\frac{1}{9}} = \frac{1}{3} \text{ rad/s}$$

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5.	Mechanical Engineering	60	30	5	10	15
6.	Production Engineering	60	30	5	10	15
7.	Chemical Engineering	30	10	5	10	5
8.	Computer Science & Engg.	30	10	5	10	5
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6.	Technical (CE • EE • ME)	100	100	90 Min.
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15. If, K_f is the fatigue stress concentration factor and K_t is the theoretical stress concentration factor then, the notch sensitivity q is?

(a) $(K_f + 1)/(K_t + 1)$ (b) $(K_f - 1)/(K_t - 1)$

(c) $(K_t - 1)/(K_f - 1)$ (d) $(K_f - 1)/(K_t + 1)$

15. ***Ans. (b)***

16. Beach or clamshell marks on a failed metallic surface are typical of

(a) Ductile fracture (b) Brittle fracture

(c) Creep failure (d) Fatigue failure

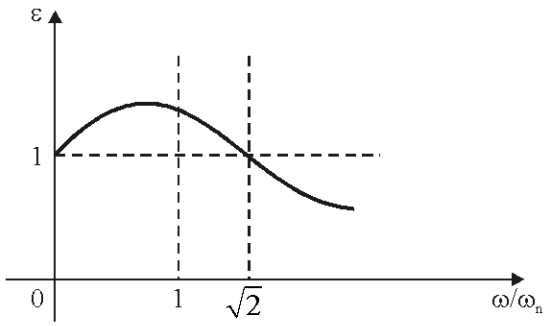
16. ***Ans. (d)***

17. In vibration isolation if ω/ω_n is less than $\sqrt{2}$ then the transmissibility will be

(a) Less than one (b) Equal to one

(c) Greater than one (d) Zero

17. ***Ans. (c)***

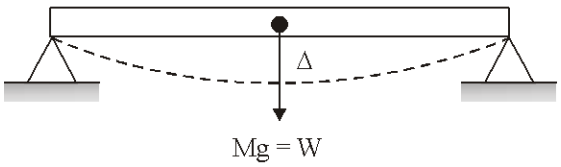


When $\frac{\omega}{\omega_n} < \sqrt{2} \Rightarrow \varepsilon > 1$

18. The natural frequency of a simply supported beam of length *l* with mass M at its centre, flexural rigidity EI and negligible beam is

(a) $\frac{1}{2\pi}\sqrt{\frac{48EI}{MI^3}}$ (b) $\frac{1}{2\pi}\sqrt{\frac{3EI}{MI^3}}$ (c) $\frac{1}{2\pi}\sqrt{\frac{EI}{MI^3}}$ (d) None of these

18. ***Ans. (a)***



Δ = Static deflection (Δ)

$= \frac{WL^3}{48EI} = \frac{mgL^3}{48EI}$

$$\omega_n = \sqrt{\frac{g}{\Delta}} = \sqrt{\frac{g}{\frac{mgl^3}{48EI}}} = \sqrt{\frac{48EI}{ml^3}}$$

$$f_n = \frac{\omega}{2\pi} = \frac{1}{2\pi}\sqrt{\frac{48EI}{ml^3}}$$

19. A machine component of natural frequency 20 rad/s is subjected to a base motion from the machine which is harmonic in nature with amplitude 3 m/s² at 10 rad/s. What is the peak amplitude of relative displacement of the components if the damping is negligible?

(a) 0.1 mm (b) 1.0 mm (c) 10.0 mm (d) 100.0 mm

19. ***Ans. (c)***

$$\omega_n = 20 \text{ rad/s}$$

$$a_{max} = 3 = \frac{F_0}{m}$$

$$\varepsilon \to 0$$

$$\omega = 10 \text{ rad/s}$$

$$\frac{\omega}{\omega_n} = \frac{10}{20} = \frac{1}{2}$$

$$A = \frac{F_0/S}{\sqrt{\left(1-\left(\frac{\omega}{\omega_n}\right)^2\right)^2 + \left(\frac{2\xi\omega}{\omega_n}\right)^0}}$$

$$= \frac{F_0/S}{1-\left(\frac{\omega}{\omega_n}\right)^2} = \frac{(F_0/m)(K/m)}{1-\left(\frac{\omega}{\omega_n}\right)^2} = \frac{(F_0/m)}{(\omega_n)^2\left(1-\left(\frac{\omega}{\omega_n}\right)^2\right)}$$

$$= \frac{\frac{a_{max}}{\omega_n^2}}{1-\left(\frac{\omega}{\omega_n}\right)^2} = \frac{3/(20)^2}{1-\left(\frac{1}{2}\right)^2}$$

$$= \frac{\frac{3}{400}}{\frac{3}{4}} = \frac{4}{400} = 0.01 \text{ meter}$$

$$= 10 \text{ mm}$$

20. In a shower mixer, cold water at 27 deg C, flowing at 5 kg/min is mixed with hot water at 77 deg C flowing at 15 kg/min. The exit temperature of the mixture is

(a) 45.4 deg C (b) 64.5 deg C

(c) 34.5 deg C (d) 68.4 deg C

20. ***Ans. (b)***

$$mC\Delta T = mC\Delta T$$

$$5 \times (T_f - 27) = 15 \times (77 - T_f)$$

$$T_f - 27 = 231^2 - 3T_f$$

$$4T_f = 231 + 27 = 258$$

$$T_f = \frac{258}{4} = 64.5$$

21. Which of the following uses a regenerator?

(a) Brayton cycle (b) Ericsson cycle

(c) Stirling cycle (d) Both (b) and (c)

21. ***Ans. (d)***

22. Ratio of convective mass transfer to the mass diffusion rate is called?

(a) Sherwood number (b) Schmidt number

(c) Rayleigh number (d) Strouhal number

22. ***Ans. (a)***

23. A gas is contained in a cylinder with a moveable piston of 100 kg mass. When 2500 J of heat flows into the gas, the internal energy of the gas increases by 1500 J. What is the distance through which the piston rises?

(a) 2 m (b) 1 m (c) 2.5 m (d) 0.5 m

23. ***Ans. (b)***

$$Q = 2500 \text{ J}$$

$$(\Delta U)_{gas} = 1500 \text{ J}$$

First Law of Thermodynamics

$$Q = (\Delta U)_{gas} + W$$

$$2500 - 1500 = 1000 = mg\Delta h$$

$$1000 = 100 \times 10' \times \Delta h$$

$$\Delta h = 1\text{m}$$

24. A refrigerator with COP of 5 is used in a room at 300 K. What will be the heat intake through a section of refrigerator wall of area 100 cm × 100 cm with a thickness of 10 cm, assuming only conduction? Value of thermal conductivity of the wall can be taken as 1 W/cmK.

(a) 5000 W (b) 1000 W (c) 7500 W (d) 3000 W

24. ***Ans. (*)***

$$COP = 5 = \frac{T_L}{T_H - T_L} = \frac{T_L}{300 - T_L}$$

$$T_L = 250 \text{ K}$$

$$q = \frac{100 \times (1 \times 1)(300 - 250)}{0.1} = 50{,}000 \text{ watt}$$

25. In a single pass rolling operation, the thickness of a 100 mm wide plate is reduced from 20 mm to 15 mm. The roller radius is 125 mm and rotational speed is 8 rpm. The average flow stress for the plate material is 400 MPa. The power required for rolling operation in kW is?

(a) $\frac{12.5\pi}{3}$ (b) 10π (c) $\frac{40\pi}{3}$ (d) $\frac{20\pi}{3}$

25. ***Ans. (d)***

$$\text{Force (F)} = \sigma_0\sqrt{R\Delta h}b$$

$$= 400\text{N/mm}^2 \times \sqrt{125\times5}\times100$$

$$= 1000\text{ kN}$$

Arm length, $a = 0.5\sqrt{125\times5} = 12.5$ mm

Torque, $T = F \times a = 1000\text{ kN} \times 12.5\text{ mm}$

Power $= 2Tw$

$$= 2 \times 1000 \times 12.5 \times \frac{2\pi\times8}{60}\text{W} = \frac{20\pi}{3}\text{kW}$$

26. A dummy activity is used in PERT network to describe

(a) Precedence relationship (b) Necessary time delay

(c) Resource restriction (d) Resource idleness

26. ***Ans. (a)***

27. In small castings, which of the following allowances can be ignored.

(a) Shrinkage Allowance (b) Rapping Allowance

(c) Draft Allowance (d) Machining Allowance

27. ***Ans. (c)***

28. In an arc welding process, two weld coupons were made using two different welding processes. For the first coupon, the voltage, current and welding speed used are 15 V, 300 A and 30 mm/min respectively. Whereas the second coupon is welded with 60 kV, 200 mA and 25 mm/s. If the heat transfer efficiency for welding the first coupon is half of that of second coupon, the ratio of heat input per unit length is?

(a) 50 : 2 (b) 75 : 8 (c) 5 : 8 (d) 5 : 2

28. ***Ans. (b)***

$V_1 = 15$ V

$V_2 = 60\text{ kW} = 60 \times 10^3\text{V}$

$I_1 = 300$ A

$I_2 = 200\text{ mA} = 200 \times 10^{-3}\text{A}$

$V_1 = 30$ mm/min

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$$= \frac{30}{60} = \frac{1}{2}\text{mm/sec}$$

$$V_2 = 25 \text{ mm/sec}$$

$$\eta_{h_1} = \frac{\eta_{h_2}}{2}$$

$$H_s = \frac{VI}{V}\eta_h J/s$$

[Heat supplied per unit length]

Ratio of heat supplied from first coupon to second.

$$\frac{H_{s_1}}{H_{s_2}} = \frac{\frac{V_1 I_1}{v_1}\eta_{h_1}}{\frac{V_2 I_2}{v_2}\eta_{h_2}} = \frac{\frac{15\times 300}{1/2}\frac{\eta_{h_2}}{2}}{\frac{60\times 10^3 \times 200\times 10^{-3}}{25}\eta_{h_2}} = \frac{75}{8}$$

$\Rightarrow \quad H_{s_1} : H_{s_2} = 75 : 8$

29. In Gas Tungsten Arc Welding (GTAW) which of the following polarity is generally used for getting higher penetration

(a) Direct Current Straight Polarity (DCSP)

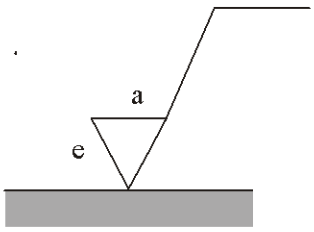
(b) Direct Current Reverse Polarity (DCRP)

(c) Alternating Current High Frequency (ACHF)

(d) All of the above

29. ***Ans. (a)***

30. What does 'a' and 'e' indicate in the surface texture symbol shown below



(a) Roughness value, machining allowance

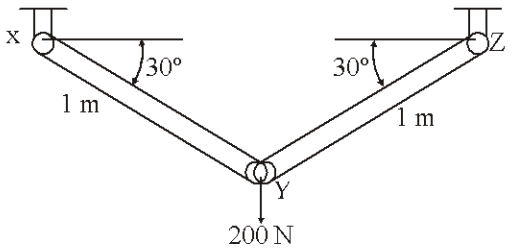
(b) Production method, roughness value

(c) Machining allowance, sampling length

(d) Heat treatment method, sample length

30. ***Ans. (a)***

31. Two steel trusses, XY and YZ of identical size supports a load of 200 N as shown in figure. The length of the truss is 1 m. The force in the truss XY in N is



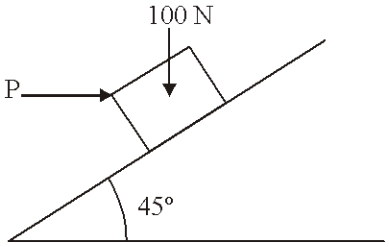
(a) 100 N (b) 200 N (c) 150 N (d) 50 N

31. ***Ans. (b)***

$$\frac{T_{xy}}{\sin 120} = \frac{T_{yz}}{\sin 120} = \frac{200}{\sin 120}$$

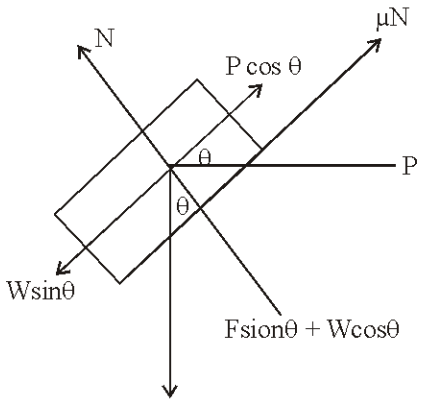
$$T_{xy} = T_{yz} = 200 \text{ N}$$

32. A block weighing 100 N is resting on a plane inclined with horizontal as shown in figure. What horizontal force P is necessary to hold the body from sliding down the plane? (Coefficient of friction can be taken as 0.25)



(a) 30 N (b) 120 N (c) 60 N (d) 15 N

32. ***Ans. (c)***



$$W\sin\theta = P\cos\theta + \mu N$$

$$W\sin\theta = P\cos\theta = \mu(W\cos\theta + P\sin\theta)$$

$$P = 60 \text{ N}$$

33. Which of the following hardness tester uses Diamond cone type indenter?

(a) Brinell (b) Vickers (c) Knoop (d) Rockwell

33. ***Ans. (d)***

34. In a two component system, if the non-compositional variable is only temperature, the number of degree of freedom in the case of a single phase field as per Gibbs Phase Rule is?

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

34. ***Ans. (d)***

$$C = 2,\ P = 1$$
$$P + F = C + 2$$
$$P + 1 = 2 + 2$$
$$F = 3$$

35. In an iron-carbon diagram, the percentage by weight of carbon at eutectoid compositon is

(a) 1.12 (b) 0.76 (c) 0.24 (d) 0.03

35. ***Ans. (b)***

36. Of the various microstructures that may be produced for a given steel alloy, which among the following is the hardest form

(a) Martensite (b) Pearlite (c) Bainite (d) Spheroidite

36. ***Ans. (a)***

37. Which spring steel is widely used for aircraft engine valves?

(a) Oil tempered wire (0.6 C to 0.7 C) (b) Chrome vanadium

(c) Hard drawn wire (0.6 C to 0.7 C) (d) Phosphor bronze wire

37. ***Ans. (b)***

38. Which of the following is a non-Newtonian fluid?

(a) Air (b) Water

(c) Gasoline (d) None of the above

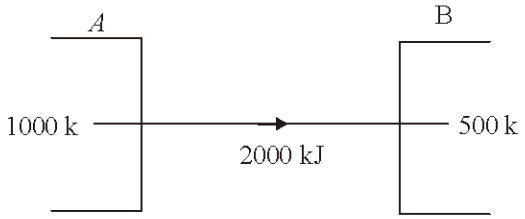
38. ***Ans. (d)***

39. A hot body at 1000K transfers 2000 kJ of heat to a body at 500K. Determine the net entropy change?

(a) +4 kJ/kg (b) – 2 kJ/kg

(c) +2 kJ/kg (d) – 4 kJ/kg

39. ***Ans. (c)***



$$\Delta S_A = \frac{-2000\,KJ}{1000\,K} = -2$$

$$\Delta S_B = \frac{2000\,KJ}{500\,K} = 4$$

$$\therefore \quad \Delta S_{net} = -2 + 4 = 2$$

40. Highest ratio of specific heat is possible for?

(a) Argon (b) Helium

(c) Hydrogen (d) Air

40. ***Ans. (a and b both)***

41. Which of the following can be used to determine the variation of saturation pressure with temperature along phase boundaries?

(a) Joule-Thomson relation (b) Carnot equation

(c) Rankine-Hougoniot's relation (d) Clausius-Clapeyron relation

41. ***Ans. (d)***

42. Air at 27°C and 100 kPa enters in a steady flow to a nozzle at a velocity of 100 m/s. If the inlet area of the nozzle is 0.5 m^2, what is the mass flow rate through the system?

(a) 116 kg/s (b) 232 kg/s

(c) 58 kg/s (d) 143 kg/s

42. ***Ans. (c)***

$$P = \rho RT$$

$$100 = \rho \times 0.287 \times 300$$

$$\rho = \frac{100}{0.287 \times 300}$$

$$\dot{m} = \frac{100}{0.28 \times 300} \times 0.5 \times 100$$

$$\dot{m} = \frac{50}{3 \times 0.28} = 50$$

$$\dot{m} = 58.07 \text{ kg/s}$$

43. Critical point of water is

(a) 22.06 kPa (b) 22.06 MPa

(c) 22.06 atm (d) 22.06 mbar

43. ***Ans. (b)***

44. For a surface, the direct and diffuse components of the solar radiation are 400 and 300 W/m^2 and the direct radiation makes 60 deg angle with the normal. If the surface temperature is 300 K and effective sky temperature is 200 K, calculate net rate of radiation heat transfer. (Assume solar absorptivity and emissivity as 0.1 each; For calculation.

Take Stefan Boltzmanns constant as 6×10^{-8} $W/m^2 K^4$)

(a) 11 W/m^2 (b) 45 W/m^2 (c) 33 W/m^2 (d) 64 W/m^2

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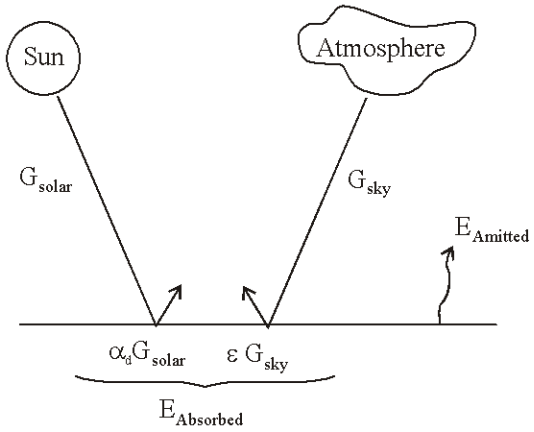
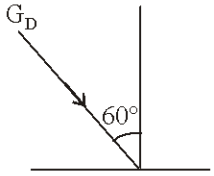
44. ***Ans. (a)***





The total solar energy incident on the surface

$$G_{solar} = (G_{Direct} \times \cos\theta) + G_{Diffuse}$$

$$= (400 \times \cos 60) + 300 W/m^2$$

$$= 500 \text{ W/m}^2$$

Net rate of radiation H.T.

$$= (\alpha_{solar} \times G_{solar}) + \in \sigma(T_{sky}^4 - T_5^4)$$

$$= (0.1 \times 500) + 0.1 \times 6 \times 10^{-8}(200^4 - 300^4) = 11 \text{ W/m}^2$$

45. Which of the following element is added to High Speed Tool Steels as a scavenger to remove slag impurities during melting and also for increasing cutting efficiency of tools.

(a) Chromium (b) Vanadium (c) Molybdenum (d) Managanese

45. ***Ans. (b)***

46. Region of disorder created by movement of dislocations in superlattice is called:

(a) Twin (b) Stacking fault

(c) Anti-phase boundary (d) Orowon loop

46. ***Ans. (c)***

47. The state of stress during deep drawing forming operation of a cup is

(a) In the flange of blank, uni-axial compression and in wall of cup, bi-axial tension and compression

(b) In the flange of blank, uni-axial tension and in wall of cup, bi-axial tension and compression

(c) In the flange of blank, uni-axial tension and compression and in the wall of cup, simple uni-axial tension

(d) Both flange and wall of the cup will have bi-axial compression and tension

47. ***Ans. (c)***

48. During turning of a metallic rod at a given condition, the tool life was found to decrease from 100 min. to 25 min. When cutting speed was increased from 50 m/min. to 100 m/min. How much will be life of tool if machined at 80 m/min?

(a) 38.06 min. (b) 39.06 min. (c) 40.06 min. (d) 41.06 min.

48. ***Ans. (b)***

$$V_1T_1^n = V_2T_2^n$$

or $$50 \times 100^n = 100 \times 25^n$$

or $$\left(\frac{100}{25}\right)^n = \frac{100}{25}$$

or $$4^n = 2$$

or $$n = 0.5$$

$$V_1T_1^n = V_3T_3^n$$

or $$50 \times 10 = 80 \times T_3^{0.5}$$

or $$\frac{25}{4} = T_3^{0.5}$$

or $$T_3 = \left(\frac{25}{4}\right)^{1/0.5} = \left(\frac{25}{4}\right)^2$$

$$= \frac{625}{16} = 39.0625 \text{ min}$$

49. The Laplace transform of $e^{at} \cos \omega t$

(a) $\frac{(s-a)}{(s-a)^2+\omega^2}$ (b) $\frac{\omega}{(s-a)^2+\omega^2}$

(c) $\frac{a}{(s-a)^2+\omega^2}$ (d) $\frac{s}{(s-a)^2+\omega^2}$

49. ***Ans. (a)***

$$L\{\cos\omega t\} = L\left\{\frac{1}{2}(e^{i\omega t} + e^{-i\omega t})\right\}$$

$$= \frac{1}{2}\left[L\{e^{i\omega t}\} + L\{e^{-i\omega t}\}\right]$$

$$= \frac{1}{2}\left[\frac{1}{s - i\omega} + \frac{1}{s + i\omega}\right]$$

$$= \frac{1}{2}\left[\frac{2s}{s^2 + \omega^2}\right] = \frac{s}{s^2 + \omega^2}$$

We know that,

if $L\{f(n)\} = F(s)$

then $L\{e^{at} f(t)\} = F(s - a)$

Hence, $L\{e^{at} \cos\omega t\} = \dfrac{s - a}{(s - a)^2 + \omega^2}$

50. If V = yzi + 3zxj + zk, then curl v is

(a) –3xi + yj + 2zk (b) 3xi – yj + 2zk

(c) –3xi – yj – 2zk (d) 3xi + yj – 2zk

50. ***Ans. (a)***

$$\vec{V} = yz\hat{i} + 3zx\hat{j} + z\hat{k}$$

$$\vec{\nabla} \times \vec{V} = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ \dfrac{\partial}{\partial x} & \dfrac{\partial}{\partial y} & \dfrac{\partial}{\partial z} \\ yz & 3zx & z \end{vmatrix}$$

$$= \hat{i}(0 - 3x) - \hat{j}(0 - y) + \hat{k}(3z - z)$$

$$= (-3x)\hat{i} + (y)\hat{j} + (2z)\hat{k}$$

51. cos(z) can be expressed as

(a) $\dfrac{1}{2}(e^{iz} + e^{-iz})$ (b) $\dfrac{1}{2}(e^{iz} - e^{-iz})$

(c) $\dfrac{1}{2i}(e^{iz} + e^{-iz})$ (d) $\dfrac{1}{2i}(e^{iz} + e^{iz})$

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51. ***Ans. (a)***

$$e^{iz} = \cos z + i\sin z \quad \text{...(i)}$$

$$e^{-iz} = \cos z + i\sin z \quad \text{...(ii)}$$

Adding equation (i) and (ii)

$$2\cos z = e^{iz} + e^{-iz}$$

Hence, $\cos z = \frac{1}{2}(e^{iz} + e^{-iz})$

52. In a vector field, Divergence of the gradient is

(a) curl (b) unity (c) zero (d) Laplacian

52. ***Ans. (d)***

$$\text{Div(Curl)} = \vec{\nabla}\cdot\vec{\nabla} = \nabla^2$$

= Laplacian Operator

53. If a continuously differentiable vector function is the gradient of a scalar function, then its curl is

(a) infinite (b) indeterminate (c) unity (d) zero

53. ***Ans. (d)***

Let $\phi(x, y, z) = c$ be a scalar function then

$$\text{grad } \phi = \hat{i}\frac{\partial\phi}{\partial x} + \hat{j}\frac{\partial\phi}{\partial y} + \hat{k}\frac{\partial\phi}{\partial z}$$

$$\text{So, curl grad } \phi = \vec{\nabla}\times\text{grad}\phi = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ \frac{\partial}{\partial x} & \frac{\partial}{\partial y} & \frac{\partial}{\partial z} \\ \frac{\partial\phi}{\partial x} & \frac{\partial\phi}{\partial y} & \frac{\partial\phi}{\partial z} \end{vmatrix}$$

$$= 0\hat{i} + 0\hat{j} + 0\hat{k} = 0$$

54. If S is the applied stress, c is the width of the crack and r the radius of curvature at the tip of the crack, Griffith's crack theory gives the concentrated stress S_e as

(a) $2S(c/r)^{1/2}$ (b) $2S(c/r)^{1/3}$ (c) $S(c/r)^{1/2}$ (d) $2S(2c/r)^{1/2}$

54. ***Ans. (a)***

55. A metal alloy machine component is subjected to fluctuating tensile stress from 100 N/mm² to 200 N/mm2. the material has yield and endurance strength of 450 and 200 N/mm² respectively. Find the factor of safety of the machine component.

(a) 5/6 (b) 12/7 (c) 1/3 (d) 6/5

55. ***Ans. (b)***

$$\sigma_{max} = 200 \text{ N/mm}^2$$

$$\sigma_{min} = 100 \text{ N/mm}^2$$

$$\sigma_m = \frac{\sigma_{max} + \sigma_{min}}{2} = \frac{200+100}{2} = 150 \text{ N/mm}^2$$

$$\sigma_y = \frac{\sigma_{max} - \sigma_{min}}{2} = \frac{200-100}{2} = 50 \text{ N/mm}^2$$

$$k_f = 1 \text{ (assumed)}$$

$$\frac{1}{N} = \frac{150}{450} + \frac{(k_f)50}{200}$$

$$N = \frac{12}{7}$$

56. A diver of mass 100 kg is standing at the tip of a spring board of negligible mass. The natural frequency of the spring board with the diver is 1.6 Hz. What is the static deflection at the tip of the spring board when the diver is standing at the tip?

(a) 0.1 mm (b) 981 mm (c) 98.1 mm (d) 9.81 mm

56. ***Ans. (c)***

Here $f_n = 1.6$ Hz

$$\omega_n = 2\pi f_n = 2\pi \times 1.6$$

$$= 3.2\ \pi \text{ rad/s}$$

By Rayleigh's method, if Δ = Static Deflection, then

$$\omega_n = \sqrt{\frac{g}{\Delta}}$$

$$3.2\pi = \sqrt{\frac{9.81}{\Delta}}$$

$$(3.2\ \pi)^2 = \frac{9.81}{\Delta}$$

$$\Delta = \frac{9.81}{(3.2\pi)^2} = 0.09706 \text{ meter}$$

$$\Delta = 97.06 \text{ mm}$$

Closest answer is 98.1 mm.

57. Which of the following is classified as a secondary bond in materials?

(a) Ionic bonding (b) Covalent bonding

(c) Metallic bonding (d) Hydrogen bonding

57. ***Ans. (d)***

58. The number of atoms per unit cell for a FCC crystal structure is

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

58. ***Ans. (b)***

59. A centrifugal pump having an impeller diameter of 127 mm, delivers a power of 12 hp. If the impeller diameter is changed to 254 mm, what is the power, if other parameters are kept constant?

(a) 48 hp (b) 192 hp (c) 24 hp (d) 96 hp

59. ***Ans. (a)***

From similitude

$$P \propto D^2H^{3/2}$$

$$\frac{P_1}{P_2} = \left(\frac{D_1}{D_2}\right)^2$$

$$\frac{12}{P_2} = \left(\frac{127}{254}\right)^2$$

$$P_2 = 12 \times 4 = 48 \text{ HP}$$

60. In a circular tube of diameter 100 mm and length 13 m with laminar low, the friction factor is estimated to be 0.05. Calculate the Reynolds number?

(a) 950 (b) 2300

(c) 1280 (d) None of the above

60. ***Ans. (c)***

$$f = \frac{64}{Re}$$

$$Re = \frac{64}{f} = \frac{64}{0.05}$$

$$= 1280$$

61. An open tank is filled with water to a height of 20 m. What is the velocity of the water flow at the outlet, if the outlet is at the base of the tank?

(a) 40 m/s (approx.) (b) 20 m/s (approx.)

(c) 10 m/s (approx.) (d) 5 m/s (approx.)

61. ***Ans. (b)***

$$V = \sqrt{2gH} = \sqrt{2 \times 10 \times 20} = 20 \text{ m/s}$$

62. For a non-dimensional specific speed value of 1, for maximum efficiency, which of the following turbines is preferred?

(a) Pelton wheel (b) Francis turbine

(c) Kaplan turbine (d) Tyson wheel

62. ***Ans. (c)***

From $K_S = \dfrac{N_S}{\sqrt{\rho}\cdot g^{5/4}}$

$$1 = \frac{N_S}{\sqrt{1000}\times(9.81)^{5/4}}$$

$$N_S = 549.01 > 300$$

So, Kaplan turbine

63. An experiment is conducted with a fluid of density 1 kg/m³ at 10 m/s velocity. The free stream static pressure is 100 kPa and the local static pressure is 101 kPa. What is the pressure coefficient at the location?

(a) 70 (b) 80 (c) 20 (d) 50

63. ***Ans. (c)***

$$\text{Pressure coefficient} = \frac{\Delta P}{\frac{1}{2}\rho U^2} = \frac{(101-100)\times 10^3}{\frac{1}{2}\times 1\times 10^2} = 20$$

64. In a P-V diagram of a steady flow compressor, the intercooling can be represented as

(a) Vertical line (b) Horizontal line

(c) Parabolic line (d) None of the above

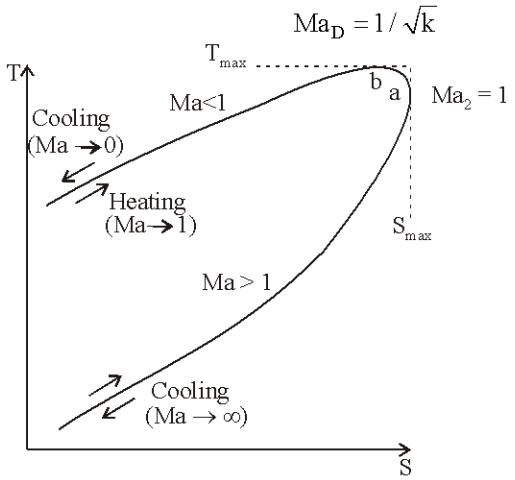
64. ***Ans. (b)***

65. Which of the following statement is true for a Rayleigh flow at M = 1?

(a) Enthalpy is maximum (b) Entropy is maximum

(c) Enthalpy is minimum (d) Both (b) and (c)

65. ***Ans. (b)***



Entropy increases with heat gain, and thus we proceed to the right on the Rayleigh line as heat is transferred to the liquid. The Mach number is Ma = 1 at point a, which is the point of maximum entropy.

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SSC-JE-2019 CBT Exam Pattern

Total Questions : 200	Total Marks : 200	Total Time : 2Hrs
Technical Section 100 Marks	General Intelligence & Reasoning 50 Marks	General Awareness 50 Marks

SSC-JE 2019 CBT Streams — Civil Engineering , Mechanical Engineering & Electrical Engineering.

CBT Registration Details : GATE-2020

Registration Start Date	:	1 September 2019
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GATE 2020 Mock Test Date	:	25 January 2020
GATE 2020 CBT Result Date	:	27 January 2020

CBT Registration Details : SSC-JE 2019

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66. A fluid passes through a well insulated tube of 4.7 cm^2 cross section area and 5 m length. If the pipe friction coefficient is 0.07 and the flow velocity is 3 m/s, then the flow can be represented using?

(a) Rayleigh flow model
(b) Isentropic flow model
(c) Gino flow model
(d) Fanno flow model

66. ***Ans. (d)***

Fanno flow is the adiabatic flow through a constant area duct where the effect of friction is considered.

67. A fluid having a density of 1 g/cc is in a state with Grashof number 2×10^6 and prandtl number 0.7. Assuming acceleration due to gravity as 10 m/s^2, calculate the Rayleigh number?

(a) 1.4×10^6 (b) 2.86×10^6 (c) 3.7×10^6 (d) 8.4×10^6

67. ***Ans. (a)***

$$R_a = G_r \times P_r = 2 \times 10^6 \times 0.7 = 1.4 \times 10^6$$

68. A cold liquid enters a counter flow heat exchanger at 15 deg at a rate of 8 kg/s. A hot stream of the same liquid enters the heat exchanger at 75 deg at 2 kg/s. Assuming the specific heat of the fluid as 4 kJ/kg°C, determine the maximum heat transfer rate.

(a) 960 kW (b) 240 kW (c) 1920 kW (d) 480 kW

68. ***Ans. (d)***

Maximum heat transfer rate in heat exchanger

$$= (\dot{m}C_p)_{min} \times (T_{h_i} - T_{c_i})$$

$$= (2 \times 4)(75 - 15)$$

$$= 480 \text{ kW}$$

69. The temperature of a surface with 0.2 m2 area is 17 deg C. Calculate the wavelength corresponding to maximum monochromatic emissive power

(a) 20 micrometers
(b) 30 micrometers
(c) 10 micrometers
(d) 40 micrometers

69. ***Ans. (c)***

Wien's Displacement Law:

Assuming body as black body,

$$\lambda_m T = 2898 \mu mK$$

$$\lambda_m = \frac{2898}{T}$$

$$= \frac{2898}{(17+273)} = 9.993 \ \mu m$$

$$\approx 10 \ \mu m$$

70. When the axes of first and last gear are co-axial, then gear train is known as

(a) simple gear train (b) compound gear train

(c) reverted gear train (d) epicyclic gear train

70. ***Ans. (c)***

71. A disc spinning on its axis at 20 rad/s will undergo precession when a torque 100 N-m is applied about an axis normal to it. If the mass moment of inertia is 1 kg-m^2, then the angular velocity of precession is?

(a) 0.2 rad/s (b) 5 rad/s (c) 10 rad/s (d) 200 rad/s

71. ***Ans. (b)***

$$\omega = 20 \text{ rad/s}$$

Gyroscopic couple,

$$C = 100 \text{ N-m}$$

$$I = 1 \text{ kg-m}^2$$

$$\omega_p = ?$$

$$C = I \times \omega \times \omega_p$$

$$100 = 1 \times 20 \times \omega_p$$

$$\omega_p = 5 \text{ rad/s}$$

72. Which of the following is an absorption type dynamometer?

(a) Prony brake dynamometer (b) Epicyclic-train dynamometer

(c) Torsion dynamometer (d) Belt transmission dynamometer

72. ***Ans. (a)***

Absorption Dyanmometers

1. Prony brake dynamometer
2. Rope brake dynamometer
3. Hydraulic dynamometer

73. Which of the following mechanism provides intermittent rotary motion?

(a) Chebyschev Linkage (b) Geneva Mechanism

(c) Peaucellier Mechanism (d) Roberts Mechanism

73. ***Ans. (b)***

There are two intermittent motion mechanisms

1. Geneva mechanism
2. Ratchet mechanism

74. If m, n are integers and m + n is odd then the value of $\int_0^{\pi} \sin mx.\cos nx.dx$ is

(a) 0 (b) $\frac{\pi}{2}$ (c) π (d) 1

74. ***Ans. (a)***

$$I = \int_0^{\pi} \sin(mx) - \cos(nx)dx$$

$$= \frac{1}{2}\int_0^{\pi} [\sin(m+n)x + \sin(m-n)x]dx$$

$$= \left[\frac{-\cos(m+n)x}{m+n} + \frac{-\cos(m-n)x}{m-n}\right]^{\pi/2}$$

$$= -\left\{\frac{\cos(m+n)\frac{\pi}{2} - 1}{m+n}\right\} - \left\{\frac{\cos(m-n)\frac{x}{2} - 1}{m-n}\right\}$$

$= 0 - 0 = 0$

$\{\because$ m + n is integer $\Rightarrow$ m – n is also an integer$\}$

75. $1 + x + \frac{x^2}{2} - \frac{x^4}{8} - \frac{x^5}{15} + \ldots\ldots =$

(a) $e^{\tan x}$ (b) $e^{\cos x}$ (c) $e^{\sin x}$ (d) $e^x \sin x$

75. ***Ans. (c)***

Let us take option (c) i.e.,

$f(x) = e^{\sin x} \Rightarrow f(0) = 1$

$f'(x) = e^{\sin x} \cdot \cos x \Rightarrow f'(0) = 1$

$f''(x) = e^{\sin x} \cdot \cos^2 x - e^{\sin x} \sin x$

$\Rightarrow \quad f''(0) = 0$

Similarly $f'''(0) = 0$

$f^{iv}(0) = -3$ ....

Now Maclurin series expansion of f(x) is

$f(x) = f(0) + xf'(0)$

$$+ \frac{x^2}{2!}f''(0) + \frac{x^3}{3!}f'''(0) + \frac{x^4}{4!}f''''(0) + \ldots..$$

$$= 1 + x + \frac{x^2}{2} - \frac{x^4}{8} - \ldots..$$

76. A cylindrical pressure vessel has diameter 200 mm and thickness 2 mm. Find the hoop and axial stress (N/mm^2) in the cylindrical vessel, when it is subjected to an internal pressure of 5 MPa.

(a) 125, 125 (b) 125, 250 (c) 250, 125 (d) 250, 125

76. ***Ans. (d)***

$$\sigma_{hoop} = \frac{pd}{2t} = \frac{5 \times 200}{2 \times 2} = 250 \text{ MPa}$$

$$\sigma_{LONG} \text{ or } \sigma_{axial} = \frac{1}{2}\sigma_{hoop} = 125 \text{ MPa}$$

77. For a long slender column of uniform cross-section, the ratio of critical buckling load for the case with both ends hinged to the case with both ends clamped is

(a) 0.25 (b) 4.0 (c) 0.125 (d) 0.5

77. ***Ans. (a)***

$$\frac{P_{b1}}{P_{b2}} = \frac{\frac{\pi^2 EI_{min}}{L^2}}{\frac{4\pi^2 EI_{min}}{L^2}} = 0.25$$

78. If the length of a column subjected to compressive load is increased by three times its original length, the critical buckling load becomes

(a) 1/3 of the original value (b) 3 times the original value

(c) 1/9 of the original value (d) 1/27 of the original value

78. ***Ans. (c)***

$$P_b = \frac{\pi^2 EI_{min}}{Le^2}$$

$$P_b \propto \frac{1}{Le^2}$$

So, $1/9^{th}$ of the original.

79. A square bar of size 10 mm × 10 mm and length 1000 mm is subjected to 200 N axial tensile force. The bar is made of mild steel having modulus of elasticity of 200 GPa. Find the strain energy density stored in the bar under this state of loading?

(a) 10 J/m^3 (b) 20 J/m^3 (c) 2 J/m^3 (d) 5 J/m^3

79. ***Ans. (a)***

Strain energy per unit volume = modulus of resilience

$$= \frac{\sigma_a^2}{2E} = \frac{(P/A)^2}{2E}$$

$$= \frac{\left(\frac{200}{10 \times 10}\right)^2}{2 \times 200 \times 10^3} = \frac{1}{10^5} N - mm/mm^3 = 10 \text{ N-m/m}^3$$

80. A solid circular shaft needs to be designed to transmit a torque of 55 Nm. If the allowable shear stress of the material is 280 N/mm², find the diameter (in mm) of the shaft required to transmit the torque. (Assume, $\pi = 22/7$)

(a) 5.62 (b) 10 (c) 31.62 (d) 25.0

80. ***Ans. (b)***

$$d^3 = \frac{16T}{\pi\tau_{per}} = \frac{16 \times 55 \times 10^3}{\frac{22}{7} \times 280}$$

$$d = 10 \text{ mm}$$

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