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ESE – 2019
(PRELIMS)

Questions with Detailed Solutions

MECHANICAL ENGINEERING

SET - A

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ESE – 2019 Prelims Examination

MECHANICAL ENGINEERING

Subject wise Weightage

SUBJECT	No. of Questions
Power plant and Turbo-machinery	18
Fluid Mechanics and hydraulic machine	17
Mechatronics and Robotics	17
Theory of Machines	15
Strength of Material	15
Material Science	11
Renewable energy	11
Refrigeration & Air Conditioning	8
Basic Thermodynamics	7
Heat Transfer	7
Production Engineering	6
Machine Design	6
IC Engines	4
IM & OR	3
Maintenance Engineering	3
Engineering Mechanics	2
Total	**150**

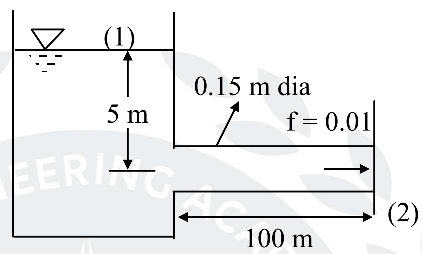
01. Water is discharged from a tank maintained at a constant head of 5 m above the exit of a straight pipe 100 m long and 15 cm in diameter. If the friction coefficient for the pipe is 0.01, the rate of flow will be nearly

(a) 0.04 m^3/s (b) 0.05 m^3/s (c) 0.06 m^3/s (d) 0.07 m^3/s

01. Ans: (c)

Sol: Applying energy equation between points 1 and 2.

$$\frac{P_1}{\gamma}+\frac{V_1^2}{2g}+Z_1=\frac{P_2}{\gamma}+\frac{V_2^2}{2g}+Z_2+h_f$$



But P_1 and $P_2 = P_{atm} = 0$

$V_1 = 0$; $Z_1 = 5$ m and $Z_2 = 0$

$$0+0+5=0+\frac{V_2^2}{2g}+0+\frac{fLV_2^2}{2gd}$$

or $$\frac{V_2^2}{2g}\left(1+\frac{fL}{d}\right)=5$$

$$V_2^2=\frac{5\times2\times9.81}{1+\frac{0.01\times100}{0.15}}$$

$$=\frac{98.1}{1+6.67}=\frac{98.1}{7.67}=12.79$$

$V_2 = 3.576$ m/s

Thus,

$$\text{Discharge}=\frac{\pi}{4}\times0.15^2\times3.576$$

$$=0.063\ m^3/s$$

Note: If the head loss at entry to the pipe is also considered then the discharge is calculated as 0.0612 m^3/s.

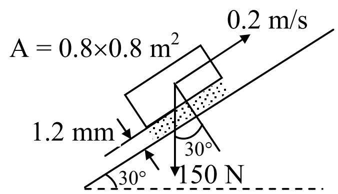
End of Solution

02. A plate weighting 150 N and measuring 0.8 m × 0.8 m just slides down an inclined plane over an oil film of 1.2 mm thickness for an inclination of 30° and velocity of 0.2 m/s. Then the viscosity of the oil used is

(a) 0.3 $N.s/m^2$ (b) 0.4 $N.s/m^2$ (c) 0.5 $N.s/m^2$ (d) 0.7 $N.s/m^2$

02. Ans: (d)

Sol: $\tau = \mu \dfrac{dv}{dy} = \mu \times \dfrac{0.2}{1.2\times10^{-3}}$



$F_{Shear} = \tau \times A$

$= \mu \times \dfrac{0.2}{1.2\times10^{-3}} \times 0.8\times0.8$

Thus,

$\mu \times \dfrac{0.2\times0.64}{1.2\times10^{-3}} = 150\times\sin30°$

$\mu = 150\times\dfrac{1}{2}\times\dfrac{1.2\times10^{-3}}{0.2\times0.64} = 0.703$ Pa.s

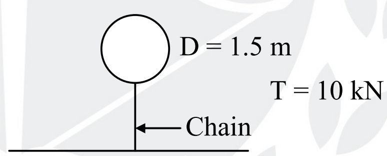
End of Solution

03. A spherical balloon of 1.5 m diameter is completely immersed in water and chained to the bottom. If the chain has a tension of 10 kN, the weight of the balloon will be nearly

(a) 9.11 kN (b) 8.22 kN (c) 6.44 kN (d) 7.33 kN

03. Ans: (d)

Sol: Under equilibrium condition:



$W_{baloon} + T_{chain} = F_B$

or, $W_{baloon} = F_B - T_{chain}$

$= \gamma_w \times \dfrac{4}{3}\pi\times0.75^3 - 10$

$= 7.33$ kN

End of Solution

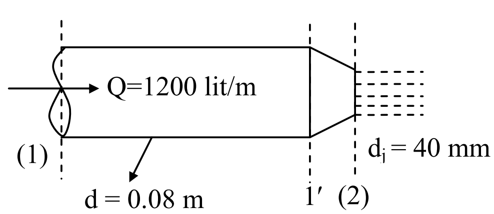
04. A nozzle at the end of an 80 mm hosepipe produces a jet 40 mm in diameter. When it is discharging the water 1200 Lpm, the force on the joint at the base of the nozzle will be

(a) 180 N (b) 200 N (c) 220 N (d) 240 N

04. Ans: (d)

Sol: $V_j = \dfrac{Q}{A_j} = \dfrac{4Q}{\pi d_j^2} = \dfrac{4\times1200\times10^{-3}}{60\times\pi\times0.04^2} = 15.915$ m/s

Thus, $V_1 = \dfrac{15.915}{4} = 3.98\,m/s$ (as $d_1 = 2\,d_j$)



$$\frac{P_1}{\gamma}+\frac{V_1^2}{2g}=\frac{P_2}{\gamma}+\frac{V_2^2}{2g}=\frac{V_2^2}{2g}$$

$$P_1=\frac{(V_2^2-V_1^2)}{2g}\times\rho g=118.72\text{ kPa gauge}$$

Applying linear momentum equation :

$$(P_1)_g\times\frac{\pi}{4}d^2-F=10^3\times\frac{1200\times10^{-3}}{60}(15.915-3.98)$$

$$F=118.72\times10^3\times\frac{\pi}{4}\times0.08^2-\frac{1200}{60}\times11.935$$

$$=596.75-238.7=358\text{ N}$$

In the above solution, if pressure force is neglected, then, F = 238.7 N

and option (d) will be the answer from the options given.

However, F = 358 N should be the answer as we cannot ignore the pressure force.

End of Solution

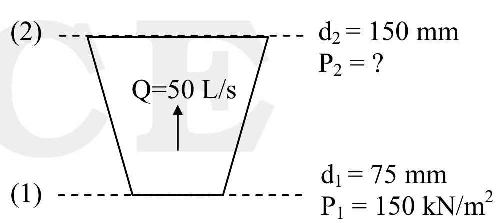
05. A vertical water pipe, 1.5 m long, tapers from 75 mm diameter at the bottom to 150 mm diameter at the top and the rate of flow is 50 L/s upwards. If the pressure at the bottom end is 150 kN/m^2, the pressure at the top will be nearly

(a) 195.2 kN/m^2 (b) 191.4 kN/m^2 (c) 187.6 kN/m^2 (d) 183.8 kN/m^2

05. Ans: (a)

Sol: Applying Bernoulli's equation

$$\frac{P_1}{\gamma_w}+\frac{V_1^2}{2g}+Z_1=\frac{P_2}{\gamma_w}+\frac{V_2^2}{2g}+Z_2$$



$$V_1=\frac{4Q}{\pi d_1^2}=\frac{4\times50\times10^{-3}}{\pi\times0.075^2}=11.32\text{ m/s}$$

Since d_2 is $2\times d_1$,

$$V_2=\frac{11.32}{4}=2.83\text{ m/s}$$

Thus, $$\frac{P_2}{\gamma_w}=\frac{150\times10^3}{9810}+\frac{11.32^2-2.83^2}{2\times9.81}-1.5$$

$$P_2=150\times10^3+\frac{(11.32^2-2.83^2)}{2}\times10^3-1.5\times9810$$

$= (150 + 60 – 14.715) \times 10^3$ N

$= 195.3$ kN/m^2

06. The stream function for a flow field is $\psi = 3x^2y + (2 + t)y^2$. The velocity at a point P for position vector r = i + 2j – 3k at time t = 2 will be

(a) 19i – 12j (b) 21i – 12j (c) 19i + 22j (d) 21i + 22j

06. Ans: (a)

Sol: Given :

$$\psi = 3x^2y + (2+t)y^2$$

The velocity components

$$u = -\frac{\partial \psi}{\partial y} = -[3x^2 + 2(2+t)y]$$

and $$v = \frac{\partial \psi}{\partial x} = 6xy$$

Position vector, r = i + 2j – 3k

So, the point coordinates are (1, 2, – 3)

Thus, $$u|_{1,2,-3\&t=2} = -[3\times 1^2 + 2(2+2)\times 2]$$

$$= -[3+16] = -19 \text{ units}$$

and $$v|_{1,2,-3\&t=2} = 6\times 1\times 2 = 12 \text{ units}$$

Hence, the required velocity is,

$$\vec{V} = -19\hat{i} + 12\hat{j} \text{ units}$$

However, if $u = \frac{\partial \psi}{\partial y}$ and $v = -\frac{\partial \psi}{\partial x}$

then, $$\vec{V} = 19\hat{i} - 12\hat{j}$$

Hence, according to the options given, the correct answer is option (a).

End of Solution

07. In a laminar flow through pipe, the point of maximum instability exists at a distance of y from the wall which is

(a) $\frac{3}{2}$ of pipe radius R (b) $\frac{2}{3}$ of pipe radius R

(c) $\frac{1}{2}$ of pipe radius R (d) $\frac{1}{3}$ of pipe radius R

07. Ans: (b)

08. $Q = \frac{\partial u'}{\partial x} = -\frac{\partial v'}{\partial y}$ for a turbulent flow signifies

(a) conservation of bulk momentum transport

(b) increase in u′ in x-direction followed by increase in v′ in negative y-direction

(c) turbulence is anisotropic

(d) turbulence is isotropic

08. Ans: (b)

Sol: $Q = \frac{\partial u'}{\partial x} = -\frac{\partial v'}{\partial y}$ for turbulent flow signifies that increase in u′ in x-direction is followed by increase in v′ in negative y-direction.

End of Solution

09. A flow field satisfying $\nabla.\vec{V} = 0$ as the continuity equation represents always

(a) a steady compressible flow

(b) an incompressible flow

(c) an unsteady and incompressible

(d) an unsteady and compressible flow

09. Ans: (b)

Sol: The general form of the continuity equation is

$$\frac{\partial \rho}{\partial t} + \vec{\nabla}.(\rho \vec{V}) = 0$$

For incompressible flow ρ = constant and the above equation reduces to

$$\vec{\nabla}.\vec{V} = 0$$

Hence, the above equation always represents an incompressible flow.

End of Solution

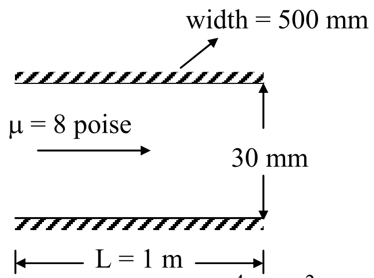
10. An oil of viscosity 8 poise flows between two parallel fixed plates, which are kept at a distance of 30 mm apart. If the drop of pressure for a length of 1 m is $0.3 \times 10^4 N/m^2$ and width of the plates is 500 mm, the rate of oil flow between the plates will be

(a) $4.2 \times 10^{-3} m^3/s$ (b) $5.4 \times 10^{-3} m^3/s$

(c) $6.6 \times 10^{-3} m^3/s$ (d) $7.8 \times 10^{-3} m^3/s$

10. Ans: (a)

Sol:



$\Delta P = 0.3 \times 10^4 \text{ N/m}^2$

For laminar flow through parallel plates separated by distance h, ΔP is given as :

$$\Delta P = \frac{12\mu VL}{h^2}$$

$$\frac{\Delta P}{L} = \frac{12\mu V}{h^2}$$

or, $$0.3 \times 10^4 = \frac{12 \times (8 \times 0.1) \times V}{0.03^2}$$

or, $V = 0.28125$ m/s

So, discharge will be

$Q = V \times \text{Area}$

$= 0.28125 \times \text{width} \times h$

$= 0.28125 \times 0.5 \times 0.03$

$= 4.22 \times 10^{-3}\ m^3/s$

End of Solution

11. In case of transmission of hydraulic power by a pipeline to a turbine in a hydroelectric power station, the maximum power transmission efficiency through the pipeline is

(a) 76 % (b) 67 % (c) 54 % (d) 42 %

11. Ans: (b)

Sol: For maximum power transmission, head loss due to friction in the pipeline,

$$h_f = \frac{H}{3}$$

Thus, the maximum power transmission efficiency

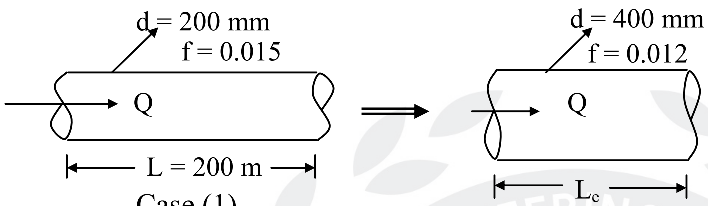
$$\eta_{max} = \frac{H - h_f}{H} = \frac{H - H/3}{H} = \frac{2}{3} = 67\%$$

12. A pipe, having a length 200 m and 200 mm diameter with friction factor 0.015, is to be replaced by a 400 mm diameter pipe of friction factor 0.012 to convey the same quantity of flow. The equivalent length of the new pipe for the same head loss will be

(a) 8300 m (b) 8240 m (c) 8110 m (d) 8000 m

12. Ans: (d)

Sol:



Case (1) Case (2)

Case (1)

$$h_{f_1} = \frac{f_1 L_1 Q_1^2}{12.1 d_1^5}$$

Case (2)

$$h_{f_2} = \frac{f_2 L_2 Q_2^2}{12.1 d_2^5}$$

Given that $Q_1 = Q_2$

$h_{f_1} = h_{f_2}$

So, $$\frac{f_1 L_1}{12.1 d_1^5} = \frac{f_2 L_2}{12.1 d_2^5}$$

where, $L_2 = L_e$ = Equivalent length of the new pipe

or $$L_e = \frac{f_1}{f_2} \times \left(\frac{d_2}{d_1}\right)^5 \times L_1 = \frac{0.015}{0.012} \times \left(\frac{400}{200}\right)^5 \times 200$$

$$= \frac{15}{12} \times 32 \times 200 = 8000\,\text{m}$$

End of Solution

13. Certain quantities cannot be located on the graph by a point but are given by the area under the curve corresponding to the process. These quantities in concepts of thermodynamics are called as

(a) cyclic functions (b) point functions

(c) path functions (d) real functions

13. Ans: (c)

14. When 25 kg of water at 95°C is mixed with 35 kg of water at 35°C, the pressure being taken as constant at surrounding temperature of 15°C, and C_p of water is 4.2 kJ/kg K, the decrease in available energy due to mixing will be nearly

(a) 270.5 kJ (b) 277.6 kJ (c) 281.8 kJ (d) 288.7 kJ

14. Ans: (c)

Sol: $m_1(T_1 - T_f) = m_2(T_f - T_2)$

$m_1 = 25$ kg, $T_1 = 95°C$

$m_2 = 35$ kg, $T_2 = 35°C$

$25(95 - T_f) = 35(T_f - 35)$

$$T_f = \frac{25\times95+35\times35}{25+35} = \frac{2375+1225}{60} = 60°C$$

$$(ds)_{univ} = m_1C_p\ell n\left(\frac{T_f}{T_1}\right)+m_2C_p\ell n\left(\frac{T_f}{T_2}\right)$$

$$= 25\times4.2\ell n\left(\frac{333}{368}\right)+35\times4.2\times\ell n\left(\frac{333}{308}\right)$$

$$= -10.494 + 11.472 = 0.9782 \text{ kJ/K}$$

Decrease in available energy = $T_o(ds)_{univ}$

$= 288\times0.9782 = 281.74$ kJ

End of Solution

15. A frictionless piston cylinder device contains 5 kg of steam at 400 kPa and 200°C. The heat is now transferred to the steam until the temperature reaches 250°C. If the piston is not attached to a shaft, its mass is constant, and by taking the values of specific volume v_1 as 0.53434 m^3/kg and v_2 as 0.59520 m^3/kg, the work done by the steam during this process is

(a) 121.7 kJ (b) 137.5 kJ (c) 153.3 kJ (d) 189.1 kJ

15. Ans: (a)

Sol: $W = mP(v_2 - v_1)$

$= 5\times400\ (0.59520 - 0.53434)$

$= 121.72$ kJ

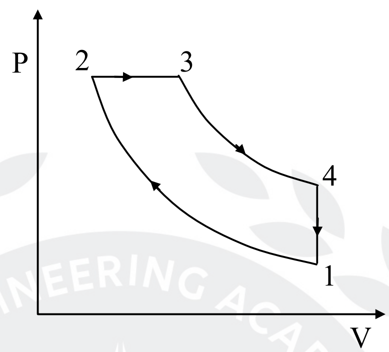
End of Solution

16. A diesel engine has a compression ratio of 14 and cutoff takes place at 6% of the stroke. The air standard efficiency will be

(a) 74.5 % (b) 60.5 % (c) 52.5 % (d) 44.5 %

16. Ans: (b)

Sol: $\frac{V_1}{V_2} = r_k = 14$



$V_3 - V_2 = 0.06(V_1 - V_2)$

$V_3 = V_2 + 0.06(14V_2 - V_2)$

$= V_2 + 0.78V_2 = 1.78\ V_2$

$\frac{V_3}{V_2} = r_C = 1.78$

$$\eta_{th} = 1 - \frac{1}{\gamma . r_k^{\gamma-1}}\left[\frac{r_c^\gamma - 1}{r_c - 1}\right]$$

$$= 1 - \frac{1}{(1.4)(14)^{(1.4-1)}}\left[\frac{1.78^{1.4} - 1}{1.78 - 1}\right]$$

$$= 1 - \frac{1.2417}{3.1382} = 0.6043 \text{ or } 60.43\%$$

End of Solution

17. A gas mixture consists of 3 kg of O_2, 5 kg of N_2 and 12 kg of CH_4. The mass fraction and mole fraction of O_2 are

(a) 0.25 and 0.125 (b) 0.15 and 0.092

(c) 0.25 and 0.092 (d) 0.15 and 0.125

17. Ans: (b)

Sol: $m_{O_2} = 3$ kg, $m_{N_2} = 5$ kg, $m_{CH_4} = 12$ kg

$$\text{Mass fraction of } O_2 = \frac{m_{O_2}}{m_{O_2} + m_{N_2} + m_{CH_4}}$$

$$= \frac{3}{3+5+12} = \frac{3}{20} = 0.15$$

$$n_{O_2} = \frac{m_{O_2}}{M_{O_2}} = \frac{3}{32}$$

$$n_{N_2} = -\frac{m_{N_2}}{M_{N_2}} = \frac{5}{28}$$

$$n_{CH_4} = \frac{m_{CH_4}}{M_{CH_4}} = \frac{12}{16} = \frac{3}{4}$$

$$\text{Mole fraction} = \frac{n_{O_2}}{n_{O_2} + n_{N_2} + n_{CH_4}}$$

$$= \frac{\frac{3}{32}}{\frac{3}{32} + \frac{5}{28} + \frac{3}{4}}$$

$$= \frac{0.09375}{0.09325 + 0.1785.7 + 0.75}$$

$$= \frac{0.09375}{1.02232} = 0.0917$$

End of Solution

18. An insulated pipe of 50 mm outside diameter with ε = 0.8 is laid in a room at 30°C. If the surface temperature is 250°C and the convective heat transfer coefficient is 10 W/m^2 K, the total heat loss per unit length of the pipe will be

(a) 896.6 W/m (b) 818.8 W/m (c) 786.4 W/m (d) 742.2 W/m

18. Ans: (b)

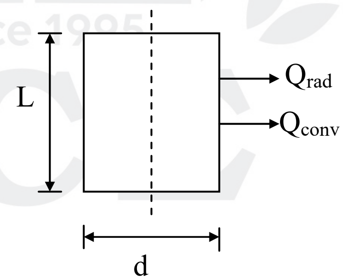
Sol: d = 50 mm

ε = 0.8

T_∞ = 30°C = 303 K

T_s = 250°C = 523 K

h = 10 W/m^2-K



Total heat loss = $Q_{convective} + Q_{Radiative}$

$$= hA(T_s - T_\infty) + \varepsilon.A\sigma(T_s^4 - T_\infty^4)$$

$$= h\pi dL(T_s - T_\infty) + \varepsilon\pi dL\sigma(T_s^4 - T_\infty^4)$$

$$= 10 \times \pi \times 0.05\ (250\text{–}30) + 0.8 \times \pi \times 0.05 \times 5.67 \times 10^{-8}\ (523^4 - 303^4)$$

Q_{total} = 818.6 W/m

End of Solution

19. A wire of 8 mm diameter at a temperature of 60°C is to be insulted by a material having k = 0.174 W/mK. The heat transfer coefficient on the outside h_a = 8 W/m^2 K and ambient temperature T_a = 25°C. The maximum thickness of insulation for maximum heat loss will be

(a) 15.25 mm (b) 16.50 mm (c) 17.75 mm (d) 18.25 mm

19. Ans: (c)

Sol: d = 8 mm, k_{ins} = 0.174 W/m.K, h_0 = 8 W/m^2K

Critical radius of insulation $(r_c) = \frac{k_{ins}}{h_0} = \frac{0.174}{8} = 0.02175\,m = 21.75$ mm

Maximum thickness = $r_c - r = 21.75 - \frac{8}{2} = 17.75$ mm

End of Solution

20. In liquid metals, thermal boundary layer develops much faster than velocity boundary layer due to

(a) lower value of Nusselt number

(b) higher value of Prandtl number

(c) lower value of Prandtl number

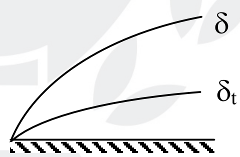
(d) higher value of Nusselt number

20. Ans: (c)

Sol: In liquid metal Prandtl number is very low (Pr << 1)

If Pr << 1

then $\delta << \delta_t$



(Hydrodynamic boundary layer thickness) << Thermal boundary layer thickness

End of Solution

21. The temperature of a body of area 0.1 m^2 is 900 K. The wavelength for maximum monochromatic emissive power will be nearly

(a) 2.3 μm (b) 3.2 μm (c) 4.1 μm (d) 5.0 μm

21. Ans: (b)

Sol: According to Wien's displacement law:

$$\lambda_{max}.T = 2898\ \mu m.K$$

$$\lambda_{max}.900 = 2898$$

$$\lambda_{max} = 3.22\ \mu m$$

22. Consider the following statements:

For the laminar condensation on a vertical plate, the Nusselt theory says that

1. inertia force in the film is negligible compared to viscosity and weight
2. heat flow is mainly by conduction through the liquid film, convection in liquid film as well as in vapour is neglected.
3. velocity of vapour is very high

Which of the above statements are CORRECT ?

(a) 1, 2 and 3 (b) 1 and 2 only (c) 1 and 3 only (d) 2 and 3 only

22. Ans: (b)

Sol: Nusselt theory for the vertical plate:

- The acceleration of condensate layer is negligible.
- Heat transfer across the liquid film is by pure conduction (no convection current and in the liquid film and vapour)
- The velocity of vapour is low (or zero) so that it exerts no drag on the condensate (no viscous shear on the liquid vapour interface).

End of Solution

23. In transition boiling, heat flux decreases due to which of the following ?

1. Low value of film heat transfer coefficient at the surface during 100°C to 120°C surface temperature.
2. Major portion of heater surface is covered by vapour film which has smaller thermal conductivity as compared to liquid.
3. Nucleate boiling occurs very fast.

Select the correct answer using the code given below.

(a) 1 only (b) 2 only (c) 3 only (d) 1, 2 and 3

23. Ans: (b)

Sol: The Heat flux decreases in the transition zone of boiling because a large fraction of the heater surface is covered by a vapour film, which acts as an insulation due to the low thermal conductivity of the vapour relative to that of the liquid.

End of Solution

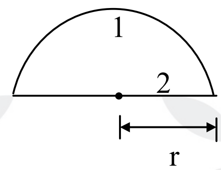
24. A hemispherical furnace of radius 1.0 m has a roof temperature of T_1 = 800 K and emissivity ε_1 = 0.8. The flat floor of the furnace has a temperature T_2 = 600 K and emissivity ε_2 = 0.5. The view factor F_{12} from surface 1 to 2 will be

(a) 0.3 (b) 0.4 (c) 0.5 (d) 0.6

24. Ans: (c)

Sol: F_{2-1} = 1 (from the geometry)

Using reciprocating theorem:



$A_1F_{1-2} = A_2F_{2-1}$

$$F_{1-2} = \frac{A_2}{A_1} \times 1$$

$$= \frac{\pi r^2}{2\pi r^2} \times 1 \quad [\text{Area of hemisphere} = 2\pi r^2]$$

$F_{1-2} = 0.5$

End of Solution

25. Consider the following statements:

Combustion chamber is

1. the volume between TDC and BDC during the combustion process
2. the space enclosed between the upper part of the cylinder and the top of the piston during the combustion process
3. the space enclosed between TDC and the top of the piston during the combustion process

Which of the above statements is/are CORRECT?

(a) 1 only (b) 2 only (c) 3 only (d) 1, 2 and 3

25. Ans: (b)

End of Solution

26. A 4-stroke diesel engine has length of 20 cm and diameter of 16 cm. The engine is producing power of 25 kW when it is running at 2500 r.p.m. The mean effective pressure of the engine will be nearly

(a) 5.32 bar (b) 4.54 bar (c) 3.76 bar (d) 2.98 bar

26. Ans: (d)

Sol: 4 stroke: P = 25 kW, l = 0.2 m

d = 0.16 m, N = 2500 rpm

$$\text{mep} = \frac{\text{Power (kW)}}{V_s(m^3)\times\frac{N}{120}(\text{rps})}$$

$$= \frac{P}{\frac{\pi}{4}D^2L\times\frac{N}{120}}$$

$$= \frac{25}{\frac{\pi}{4}(0.16)^2(0.2)\times\frac{2500}{120}} = 289.57 \text{ kPa} \quad \text{or} \quad 2.98 \text{ bar}$$

End of Solution

27. A 4-stroke, 6-cylinder gas engine with a stroke volume of 1.75 litres develops 26.25 kW at 506 r.p.m and the MEP is 600 kN/m^2. The number of misfires per minute per cylinder will be

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

27. Ans: (a)

Sol: 4-stroke gas engine :

n = 6 cylinder, $V_s = 1.75\times10^{-3}$ m^3

P = 26.25 kW, P_m = 600 kN/m^2

N = 506 rpm

$$P_m = \frac{P}{V_s\times n\times\frac{N}{120}}$$

$$600 = \frac{26.25}{1.75\times10^{-3}\times6\times\frac{N_1}{120}}$$

N_1 = 500 rpm

But N = 506 rpm

For developing the given mep only 500 rpm is required, whereas actual is 506 rpm.

$$\text{Missed firing cycles} = \frac{N-N_1}{2} = \frac{506-500}{2} = 3$$

End of Solution

28. Which one of the following compressors will be used in vapour compression refrigerator for plants up to 100 tonnes capacity ?

(a) Reciprocating compressor (b) Rotary compressor

(c) Centrifugal compressor (d) Double-acting compressor

28. Ans: (c)

Sol: High volume flow rates require centrifugal compressors.

End of Solution

29. A cold storage is to be maintained at –5°C while the surroundings are at 35°C. The heat leakage from the surroundings into the cold storage is estimated to be 29 kW. The actual COP of the refrigeration plant used is $\frac{1}{3}$rd that of an ideal plant working between the same temperatures. The power required to drive the plant will be

(a) 13 kW (b) 14 kW (c) 15 kW (d) 16 kW

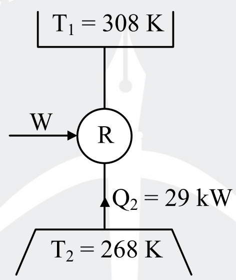
29. Ans: (a)

Sol: $COP_{Actual} = \frac{1}{3}(COP)_{theoritical}$

$$= \frac{Q_2}{W}$$

$$= \frac{1}{3}\left[\frac{T_2}{T_1 - T_2}\right] = \frac{29}{W}$$

$$= \frac{1}{3}\left[\frac{268}{308 - 268}\right] = \frac{29}{W}$$



$\Rightarrow \quad W = 12.98$ kW

End of Solution

30. Consider the following statements:

An expansion device in a refrigeration system

1. reduces the pressure form the condenser to the evaporator
2. regulates the flow of the refrigerant to the evaporator depending on the load
3. is essentially a restriction offering resistance to flow

Which of the above statements are CORRECT ?

(a) 1 and 2 only (b) 1 and 3 only

(c) 2 and 3 only (d) 1, 2 and 3

30. Ans: (d)

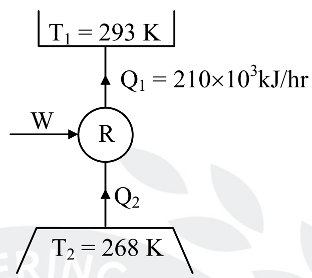
End of Solution

31. A reversed Carnot engine is used for heating a building. It supplies 210×10^3 kJ/hr of heat to the building at 20°C. The outside air is at –5°C. The heat taken from the outside will be nearly

(a) 192×10^3 kJ/hr (b) 188×10^3 kJ/hr (c) 184×10^3 kJ/hr (d) 180×10^3 kJ/hr

31. Ans: (a)

Sol: $(COP)_R = \dfrac{Q_1}{W} = \dfrac{T_1}{T_1 - T_2}$



$$\frac{210\times10^3}{W} = \frac{293}{293-268}$$

$W = 17.918\times10^3$ kJ/hr

$Q_2 = Q_1 - W$

$= 210\times10^3 - 17.918\times10^3 = 192\times10^3$ kJ/hr

End of Solution

32. In an Electrolux refrigerator, a thermo-siphon bubble pump is used to lift the

(a) weak aqua solution from the generator to the separator

(b) weak aqua solution from the separator to the absorber

(c) strong aqua solution from the generator to the separator

(d) strong aqua solution from the generator to the evaporator

32. Ans: (a)

Sol: A thermo-siphon bubble pump is used to lift weak aqua solution from the generator to the separator and then to the absorber.

End of Solution

33. The enthalpy of moist air with normal notations is given by

(a) $h = (1.005 + 1.88W)t + 2500W$

(b) $h = 1.88Wt + 2500W$

(c) $h = 1.005Wt$

(d) $h = (1.88 + 1.005W)t + 2500W$

33. Ans: (a)

Sol: $h = C_{Pa}(t-0) + W\left[(h_{fg})_{0^\circ C} + C_{Pv}(t-0)\right]$

$= 1.005(t-0) + W[2500 + 1.88(t-0)]$

$= (1.005 + 1.88W)(t-0) + 250000$

$= (1.005 + 1.88W)t + 2500\,W$

34. If the relative humidity of atmospheric air is 100%, then the wet-bulb temperature will be

(a) more than dry-bulb temperature

(b) equal to dew-point temperature

(c) equal to dry-bulb temperature

(d) less than dry-bulb temperature

34. Ans: (b) and (c)

End of Solution

35. During an air-conditioning of a plant, the room sensible heat load is 40 kW and room latent heat load is 10 kW, ventilation air is 25% of supply air. At full load, the room sensible heat factor will be

(a) 0.9 (b) 0.8 (c) 0.7 (d) 0.6

35. Ans: (b)

Sol: RSHL = 40 kW

RLHL = 10 kW

$$RSHF = \frac{RSHL}{RSHL + RLHL} = \frac{40}{40+10} = 0.8$$

End of Solution

36. A 2-stroke oil engine has bore of 20 cm, stroke 30 cm, speed 350 r.p.m, i.m.e.p. 275 kN/m^2, net brake load 610 N, diameter of brake drum 1 m, oil consumption 4.25 kg/hr, calorific value of fuel 44×10^3 kJ/kg. The indicated thermal efficiency will be

(a) 29.1% (b) 31.3% (c) 33.5% (d) 35.7%

36. Ans: (a)

Sol: 2-Stroke oil engine :

d = 0.2 m, $l = 0.3$ m, N = 350 rpm, $P_{mi} = 275\frac{kN}{m^2}$

W – S = 610 N D_i = 1 m $\dot{m}_f = 4.25$ kg/hr CV = 44000 kJ/kg.

$$I.P(kW) = \frac{P_{mi}\,L\,A\,N\,n}{60}$$

$$= \frac{275\times0.3\times\frac{\pi}{4}(0.2)^2\times350\times1}{60} = 15.1\text{ kW}$$

Indicated thermal efficiency = $\dfrac{IP(kW)\times 3600}{\dot{m}_f(kg/hr)\times C_v\left(\dfrac{kJ}{kg}\right)}$

$$= \frac{15.1\times 3600}{4.25\times 44000} = 0.2909 \text{ or } 29.1\%$$

End of Solution

37. The hydraulic efficiency of a turbine is the ratio of

(a) mechanical energy in the output shaft at coupling and hydrodynamic energy available from the fluid.

(b) mechanical energy supplied by the rotor and hydrodynamic energy available from the fluid

(c) useful hydrodynamic energy in the fluid at final discharge and mechanical energy supplied to the rotor

(d) useful hydrodynamic energy in the fluid at final discharge and mechanical energy supplied to the shaft and coupling

37. Ans: (b)

End of Solution

38. Consider the following statements regarding compounding in steam turbines:

1. In impulse turbine, steam pressure remains constant between ends of the moving blades.
2. In reaction turbine, steam pressure drops from inlet to outlet of the blade.
3. In velocity compounding, partial expansion of steam take place in the nozzle and further expansion takes place in the rotor blades.

Which of the above statements are CORRECT ?

(a) 1 and 2 only (b) 1 and 3 only (c) 2 and 3 only (d) 1, 2 and 3

38. Ans: (a)

Sol: In velocity compounding there is no pressure drop in the rotor blades. Hence, statement (3) is not correct.

End of Solution

39. In a lawn sprinkler, water leaves the jet with an absolute velocity of 2 m/s and the sprinkler arms are 0.1 m in length. The sprinkler rotates at a speed of 120 r.p.m. The utilization factor of this sprinkler will be nearly

(a) 0.72 (b) 0.64 (c) 0.56 (d) 0.49

39. Ans: (c)

Sol: Lawn sprinkler :

Given, $V_{ab} = 2$ m/s,

Arm length, $r = 0.1$ m,

$N = 120$ rpm

Angular speed, $\omega = \dfrac{2\pi N}{60} = \dfrac{2\pi \times 120}{60} = 4\pi \text{ rad/s}$

Utilization factor, $\varepsilon = \dfrac{\text{work done}}{\text{work done} + \text{K.E. loss}}$

$$= \frac{\text{Torque} \times \omega}{\text{Torque} \times \omega + \frac{1}{2}\dot{m} V^2}$$

$$= \frac{\rho \frac{Q}{2}(V_2 r_2 + V_1 r_1) \times \omega}{\rho \frac{Q}{2}(V_2 r_2 + V_1 r_1) \times \omega + \frac{\rho Q}{2} V^2}$$

But $V_2 = V_1$ & $r_1 = r_2$

$$\varepsilon = \frac{\rho Q V \times r \times \omega}{\rho Q V \times r \times \omega + \frac{\rho Q}{2} V^2}$$

$$= \frac{\omega r}{\omega r + \frac{V}{2}}$$

$$= \frac{4\pi \times 0.1}{4\pi \times 0.1 + \frac{2}{2}}$$

$$= \frac{1.257}{2.257} = 0.557 \cong 0.56$$

End of Solution

40. Which one of the following statement is correct with respect to axial flow 50% reaction turbine?

(a) The combined velocity diagram is symmetrical.

(b) The outlet absolute velocity should not be axial for maximum utilization.

(c) Angles of both stator and rotor are not identical.

(d) For maximum utilization, the speed ratio $\dfrac{U}{V_1} = \sin^2 \alpha$.

40. Ans: (a)

41. In axial flow pumps and compressors, the combined velocity diagram with common base is used to determine change in

(a) absolute velocity ($V_2 - V_1$)
(b) relative velocity ($V_{r2} - V_{r1}$)
(c) tangential velocity ($U_2 - U_1$)
(d) whirl velocity ($V_{u2} - V_{u1}$)

41. Ans: (d)

End of Solution

42. In a steam turbine with steam flow rate of 1 kg/s, inlet velocity of steam of 100 m/s, exit velocity of steam of 150 m/s, enthalpy at inlet of 2900 kJ/kg, enthalpy at outlet of 1600 kJ/kg, the power available from the turbine will be nearly

(a) 1575.5 kW (b) 1481.6 kW (c) 1387.7 kW (d) 1293.8 kW

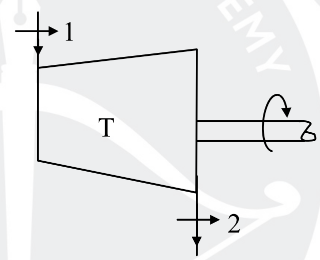
42. Ans: (d)

Sol: S.F.E.E :

$$\dot{m}\left(h_1 + \frac{c_1^2}{2000}\right) = \dot{m}\left(h_2 + \frac{c_2^2}{2000}\right) + \dot{W}_T$$

$$1\left(2900 + \frac{100^2}{2000}\right) = 1\left(1600 + \frac{150^2}{2000}\right) + \dot{W}_T$$

$$\dot{W}_T = 1293.8\,\text{kW}$$



End of Solution

43. In an isentropic flow through a nozzle, air flows at the rate of 600 kg/hr. At inlet to nozzle, the pressure is 2 MPa and the temperature is 127°C. The exit pressure is of 0.5 MPa. If the initial velocity of air is 300 m/s, the exit velocity will be

(a) 867 m/s (b) 776 m/s (c) 685 m/s (d) 594 m/s

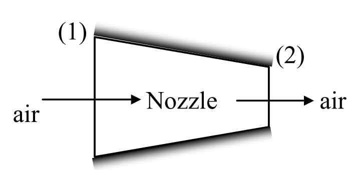
43. Ans: (d)

Sol: $\dot{m}$ = 600 kg/hr, P_1 = 2 MPa,

P_2 = 0.5 MPa, T_1 = 127°C, c_1 = 300 m/s,

$$\frac{T_2}{T_1} = \left(\frac{P_2}{P_1}\right)^{\frac{\gamma-1}{\gamma}}$$

$$\frac{T_2}{400} = \left(\frac{0.5}{2}\right)^{\frac{0.4}{1.4}}$$



T_2 = 269.18 K

S.F.E.E :

$$\dot{m}\left(c_p T_1 + \frac{c_1^2}{2000}\right) = \dot{m}\left(c_p T_2 + \frac{c_2^2}{2000}\right)$$

$$1.005 \times 400 + \frac{300^2}{2000} = 1.005 \times 269.18 + \frac{c_2^2}{2000}$$

$\therefore$ $c_2 = 594$ m/s

End of Solution

44. In a steam turbine, the nozzle angle at the inlet is 18°. The relative velocity is reduced to the extent of 6 % when steam flows over the moving blades. The output of the turbine is 120 kJ/kg flow of steam. If the blades are equiangular, the speed ratio and the absolute velocity of steam at inlet for maximum utilization are nearly

(a) 0.42 and 230.2 m/s
(b) 0.48 and 230.2 m/s
(c) 0.42 and 515.1 m/s
(d) 0.48 and 515.1 m/s

44. Ans: (d)

Sol: $\alpha = 18°$

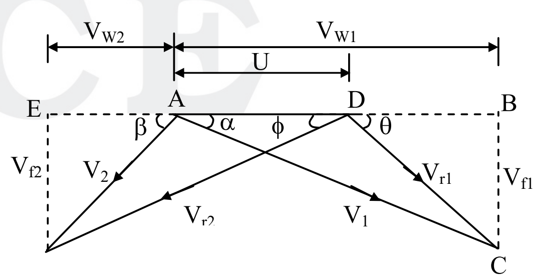
$V_{r_2} = 0.94 V_{r_1} \Rightarrow K = 0.94$

$W = 120$ kJ/kg

$\theta = \phi$ (Blades are equiangular)

Optimum blade speed ratio. $(\rho) = \dfrac{U}{V_1} = \dfrac{\cos\alpha}{2} = \dfrac{\cos 18^\circ}{2} = 0.475$

$k = \dfrac{V_{r_2}}{V_{r_1}}$, $z = \dfrac{\cos\phi}{\cos\theta} = 1.0$



$W = (V_{w_1} + V_{w_2})U$

$= (DB + DE)U$

$= (V_{r_1}\cos\theta + V_{r_2}\cos\phi)U$

$= V_{r_1}\cos\theta(1 + kz)U$

$120 \times 10^3 = (V_1\cos\alpha - U)U(1 + kz)$

$120 \times 10^3 = (V_1\cos 18^\circ - 0.475V_1)(0.475V_1)(1 + 0.94)$

$V_1^2(0.475\cos 18^\circ - 0.475^2) = 61.85 \times 10^3$

$V_1 = 522.32$ m/s

45. An air compressor compresses atmospheric air at 0.1 MPa and 27°C by 10 times of air inlet pressure. During compression, the heat lost to the surrounding is estimated to be 5% of compression work. Air enters the compressor with a velocity of 40 m/s and leaves with 100 m/s. The inlet and exit cross-sectional areas are 100 cm^2 and 20 cm^2 respectively. The temperature of air at the exit from the compressor will be

(a) 1498 K (b) 1574 K (c) 1654 K (d) 1726 K

45. Ans: (a)

Sol: $P_1 = 100$ kPa, $T_1 = 300$ K,

$P_2 = 10P_1 = 1000$ kPa, $Q_2 = 5\% \ (W_C)$,

$C_1 = 40$ m/s, $C_2 = 100$ m/s,

$A_1 = 100\times10^{-4}$ m^2, $A_2 = 20\times10^{-4}$ m^2

$$\dot{m} = \rho_1 A_1 C_1 = \rho_2 A_2 C_2$$

$$\frac{P_1}{RT_1}A_1C_1 = \frac{P_2}{RT_2}A_2C_2$$

$$\frac{P_1A_1C_1}{T_1} = \frac{P_2}{T_2}A_2C_2$$

$$\frac{100(100)(40)}{300} = \frac{1000(100)(20)}{T_2}$$

$\Rightarrow$ $T_2 = 1500$ K

End of Solution

46. A compressor delivers 4 m^3 of air having a mass of 5 kg. The specific weight and specific volume of air being delivered will be nearly

(a) 12.3 N/m^3 and 0.8 m^3/kg (b) 14.6 N/m^3 and 0.4 m^3/kg

(c) 12.3 N/m^3 and 0.4 m^3/kg (d) 14.6 N/m^3 and 0.8 m^3/kg

46. Ans: (a)

Sol: Volume = 4 m^3, m = 5 kg

$$\text{Specific volume} = \frac{V}{m} = \frac{4}{5} = 0.8\frac{m^3}{kg}$$

$$\text{Specific weight (w)} = \rho \times g = \frac{1}{\text{Sp.vol}}\times g = \frac{9.81}{0.8} = 12.26 \text{ N/m}^3$$

47. In centrifugal compressors, there exists a loss of energy due to the mismatch of direction of relative velocity of fluid at inlet with inlet blade angle. This loss is known as

(a) frictional loss (b) incidence loss (c) clearance loss (d) leakage loss

47. Ans: (b)

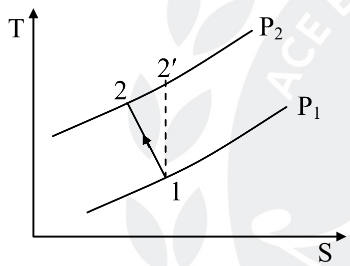
End of Solution

48. A centrifugal compressor develops a pressure ratio of 5 and air consumption of 30 kg/s. The inlet temperature and pressure are 15°C and 1 bar respectively. For an isentropic efficiency of 0.85, the power required by the compressor will be nearly

(a) 5964 kW (b) 5778 kW (c) 5586 kW (d) 5397 kW

48. Ans: (a)

Sol:



$P_1 = 100$ kPa , $\eta_c = 0.85$

$\frac{P_2}{P_1} = 5$, $\dot{m}_a = 30$ kg/s ,

$T_1 = 15 + 273 = 288$ K ,

$$T_2 = T_1\left(\frac{P_2}{P_1}\right)^{\frac{\gamma-1}{\gamma}} = 288 \times (5)^{\frac{0.4}{1.4}} = 456.14 \text{ K}$$

Ideal work $(W_c) = c_p\,(T_2 - T_1)$

$$W_c = 1.005\,(456.14 - 288) = 168.98 \text{ kJ/kg}$$

$$\eta_c = \frac{W_c}{W_c'} = \frac{\text{Ideal work}}{\text{Actual work}}$$

$$W_c' = \frac{W_c}{\eta_c} = \frac{168.96}{0.85} = 198.8 \text{ kJ/kg}$$

$\therefore$ Actual power for compressor

$$\dot{W}_c' = \dot{m}_a(W_c') = 30 \times (198.8) = 5964.02 \text{ kW}$$

49. 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

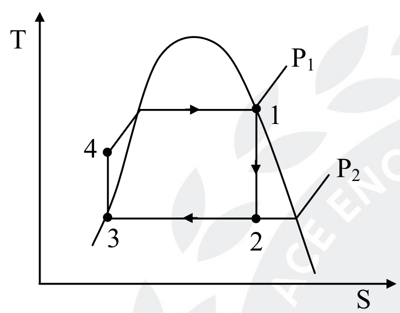
(b) the mean temperature of heat addition is higher for superheat cycle

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

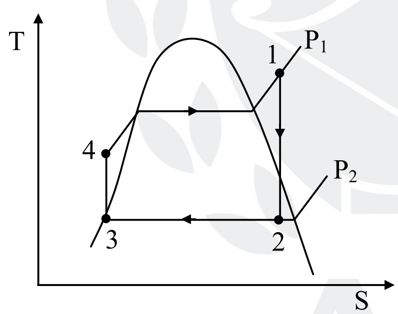
(d) the quality of steam in the condenser is low

49. Ans: (b)

Sol: Simple Rankine cycle



Superheat Rankine cycle



End of Solution

50. In steam power cycle, the process of removing non-condensable gases is called

(a) scavenging process

(b) deaeration process

(c) exhaust process

(d) condensation process

50. Ans: (b)

End of Solution

51. The internal irreversibility of Rankine cycle is caused by

1. fluid friction
2. throttling
3. mixing

Select the correct answer using the code given below.

(a) 1 and 2 only (b) 1 and 3 only (c) 2 and 3 only (d) 1, 2 and 3

51. Ans: (d)

Sol: Internal irreversibility of Rankine cycle is caused by fluid friction, throttling and mixing.

End of Solution

52. A 1 g sample of fuel is burned in a bomb calorimeter containing 1.2 kg of water at an initial temperature of 25°C. After the reaction, the final temperature of the water is 33.2°C. The heat capacity of the calorimeter is 837 J/°C. The specific heat of water is 4.18 J/°C. The heat released by the fuel will be nearly

(a) 36 kJ/g (b) 42 kJ/g (c) 48 kJ/g (d) 54 kJ/g

52. Ans: (c)

Sol: $m_f \times (HCV)_f = m_w C_{P_W} (\Delta T)_w + mc(\Delta T)_w$

$1\times(HCV)_f = 1.2\times4.18\times(33.2–25) + 0.837\times(33.2 – 25)$

$(HCV)_f = 41.132 + 6.8634$

$= 47.9954 = 48$ kJ/gm

Note: Specific heat of water is taken as 4.18 kJ/kg°C.

End of Solution

53. A boiler is having a chimney of 35 m height. The draught produced in terms of water column is 20 mm. The temperature of flue gas inside the chimney is 365°C and that of air outside the chimney is 32°C. The mass of air used will be nearly

(a) 10.3 kg/kg of fuel (b) 12.5 kg/kg of fuel

(c) 14.7 kg/kg of fuel (d) 16.9 kg/kg of fuel

53. Ans: (d)

Sol: $h_W = 353H\left[\frac{1}{T_a} - \frac{1}{T_g}\frac{m_a+1}{m_a}\right]$

$$20 = 353\times 35\left[\frac{1}{305} - \frac{1}{638}\frac{m_a+1}{m_a}\right]$$

$$1.618\times 10^{-3} = \frac{1}{305} - \frac{1}{638}\times\frac{m_a+1}{m_a}$$

$$10^{-3}(3.2786 - 1.618)\times 638 = \frac{m_a+1}{m_a}$$

$$\frac{m_a+1}{m_a} = 1.059$$

$0.059\ m_a = 1$

$\Rightarrow\quad m_a = \dfrac{1}{0.059}$ = 16.95 kg air/kg fuel

End of Solution

54. A 2 kg of steam occupying 0.3 m^3 at 15 bar is expanded according to the law $pv^{1.3}$ = constant to a pressure of 1.5 bar. The work done during the expansion will be

(a) 602.9 kJ (b) 606.7 kJ (c) 612.5 kJ (d) 618.3 kJ

54. Ans: (d)

Sol: $P_1V_1^n = P_2V_2^n$

$$V_2 = V_1\left(\frac{P_1}{P_2}\right)^{\frac{1}{n}} = 0.3\left[\frac{15}{1.5}\right]^{\frac{1}{1.3}} = 1.7634\ m^3$$

$$_1W_2 = \frac{P_1V_1 - P_2V_2}{n-1}$$

$$= \frac{1500\times 0.3 - 150\times 1.7634}{1.3-1} = \frac{450 - 264.51}{0.3} = 618.96\ \text{kJ}$$

End of Solution

55. Which of the following statements is/are correct regarding superheater in boilers ?

1. It is a heat exchanger in which heat is transformed to the saturated steam to increase its temperature.
2. It raises the overall efficiency.
3. It reduces turbine internal efficiency.

Select the correct answer using the code given below.

(a) 1 and 2 (b) 1 and 3 (c) 2 and 3 (d) 1 only

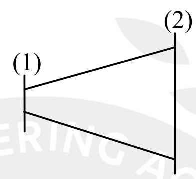
55. Ans: (a)

56. Water vapour at 90 kPa and 150°C enters a subsonic diffuser with a velocity of 150 m/s and leaves the diffuser at 190 kPa with a velocity of 55 m/s, and during the process, 1.5 kJ/kg of heat is lost to the surrounding. For water vapour, c_p is 2.1 kJ/kgK. The final temperature of water vapour will be

(a) 154°C (b) 158°C (c) 162°C (d) 166°C

56. Ans: (a)

Sol: $h_1 + \frac{V_1^2}{2000} + \frac{dQ}{dm} = h_2 + \frac{V_2^2}{2000}$



$h_2 - h_1 = \frac{V_1^2}{2000} - \frac{V_2^2}{2000} + \frac{dQ}{dm}$

$C_{pv}(T_2 - T_1) = \frac{V_1^2}{2000} - \frac{V_2^2}{2000} + \frac{dQ}{dm}$

$2.1[T_2 - 150] = \frac{150^2}{2000} - \frac{552}{2000} = 1.5$

$= 11.25 - 1.5125 - 1.5$

$T_2 - 150 = 3.92$

$T_2 = 153.92^\circ C$

End of Solution

57. A steam turbine is supplied with steam at a pressure of 20 bar gauge. After expansion in the steam turbine, the steam passes to condenser which is maintained at a vacuum of 250 mm of mercury by means of pumps. The inlet and exhaust steam pressures will be nearly

(a) 2101 kPa and 68 kPa (b) 2430 kPa and 78 kPa

(c) 2101 kPa and 78 kPa (d) 2430 kPa and 68 kPa

57. Ans: (a)

Sol: $P_{boil} = 2000 + 101.325$

$= 2101.325\,\text{kPa}$

$P_{con} = 101.325 - \frac{250}{760} \times 101.325 = 67.99\,\text{kPa}$

End of Solution

58. In a power plant, the efficiencies of the electric generator, turbine, boiler, thermodynamic cycle and the overall plant are 0.97, 0.95, 0.92, 0.42 and 0.33 respectively. The total electricity generated for running the auxiliaries will be nearly

(a) 4.9 % (b) 5.7 % (c) 6.5 % (d) 7.3 %

58. Ans: (d)

Sol: $\eta_o = \eta_{gen} \times \eta_T \times \eta_{boil} \times \eta_{th} \times \eta_{aux}$

$0.33 = 0.97 \times 0.95 \times 0.92 \times 0.42 \times \eta_{aux}$

$\eta_{aux} = 0.9267$

Electricity for auxiliaries = $1 - 0.9267 = 0.0733$ or 7.33%

End of Solution

59. A turbine in which steam expands both in nozzle as well as in blades is called as

(a) impulse reaction turbine (b) reciprocating steam turbine

(c) gas turbine (d) Curtis turbine

59. Ans: (a)

End of Solution

60. Consider the following statements regarding reaction turbine :

1. Blade shape is aerofoil type and its manufacturing is difficult.
2. It is suitable for small power.
3. Leakage losses are less compared to friction losses.

Which of the above statements is/are correct ?

(a) 1 only (b) 2 only (c) 3 only (d) 1, 2 and 3

60. Ans: (a)

End of Solution

61. The solar heat pipe works on the principle of

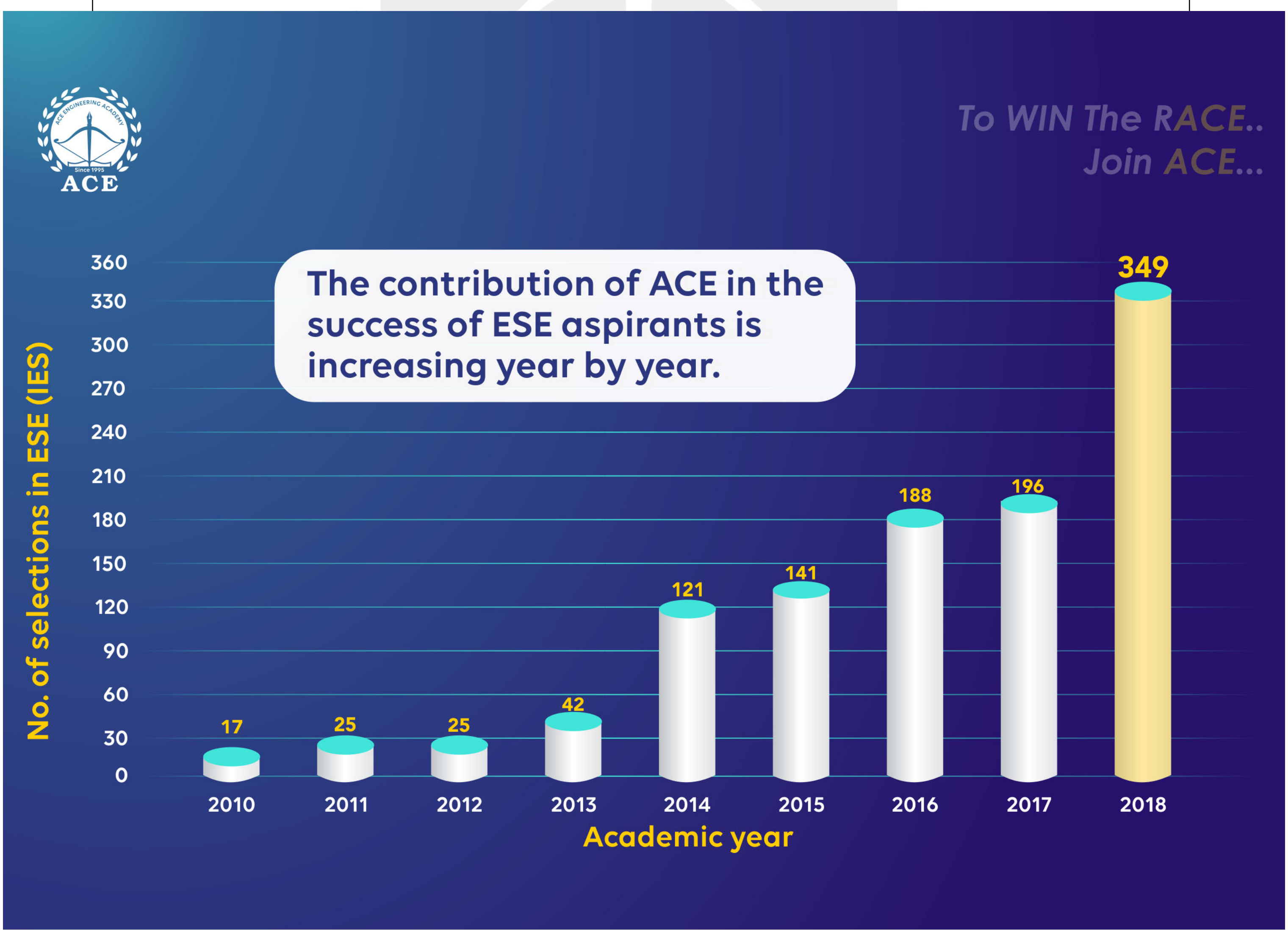
(a) heating and condensation cycle

(b) evaporation and condensation cycle

(c) cooling and condensation cycle

(d) heating and evaporation cycle

61. Ans: (b)


To WIN The RACE..
Join ACE...
The contribution of ACE in the success of ESE aspirants is increasing year by year.
No. of selections in ESE (IES)
0
30
60
90
120
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17
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2010
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2012
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2014
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2016
2017
2018
Academic year

62. A good approximation of the measured solar spectrum is made by

(a) black-body energy distribution (b) Planck's energy distribution

(c) inverse square law (d) solar constant

62. Ans: (a)

End of Solution

63. Which one of the following types of tracker uses liquid contained in canisters that can turn easily into vapour ?

(a) Active tracker (b) Passive tracker

(c) Single-axis tracker (d) Altitude-azimuth tracker

63. Ans: (b)

Sol:

- Active trackers require external power to drive tracking mechanism whereas passive trackers do not require external power.
- Passive trackers use low boiling point liquid which vapourises after absorbing solar heat. The tracker can tilt to one or other side due to imbalance caused by vapourisation of liquid.

End of Solution

64. Which type of flat-plate collector is used to heat the swimming pools with plastic panel, utilizing solar energy ?

(a) Pipe and fin type

(b) Full water sandwich type

(c) Thermal traps type

(d) Corrugated plate with selective surface type

64. Ans: (b)

Sol: Full water sandwich type: In this case, both the wetted area and the water capacity are high. Because the thermal conduction is only across the skin thickness (short distance) of the materials, low-conductivity materials may be used. Both plastic and steel are used. It is commonly used for heating swimming pools with plastic panels.

End of Solution

65. The edge loss U_e in a solar collector with respect to edge area A_e, collector area A_c and back loss coefficient U_b is

(a) $U_b\left(\frac{A_e}{A_c}\right)$ (b) $U_b\left(\frac{A_c}{A_e}\right)$ (c) $A_c\left(\frac{A_e}{U_b}\right)$ (d) $U_b\left(\frac{A_e}{2A_c}\right)$

65. Ans: (a)

Sol: Heat loss coefficient from edge is given by

$$U_e = U_b\left(\frac{A_e}{A_c}\right)$$

where, U_b = bottom loss coefficient in $W/m^2 °C$

A_e = Area of edge in m^2

A_c = Area of collector in m^2

End of Solution

66. In solar porous type air heater, the pressure drop is usually

(a) higher than non-porous type (b) same as in non-porous type

(c) lower than non-porous type (d) zero

66. Ans: (c)

Sol: The pressure drop, although the matrix hinders the air flow, is lower in porous air heater as compared with the non-porous air heaters.

End of Solution

67. In a drainback solar water heating system

(a) the water in the heat exchanger is recycled

(b) the water is heated in collectors only during times when there is available heat

(c) at the collector, the mixture of water and propylene-glycol is heated and returned to a solar storage tank

(d) there is an expansion tank with enclosed air chamber to assist water draining

67. Ans: (c)

Sol: In drain back solar water heater, a solar fluid (propylene-glycol antifreeze mixture) is recirculated between collector and heat exchanger.

End of Solution

68. A PV cell is illuminated with irradiance (E) of 1000 W/m^2. If the cell is 100 mm × 100 mm in size and produces 3 A at 0.5 V at the maximum power point, the conversion efficiency will be

(a) 15 % (b) 19 % (c) 23 % (d) 27 %

68. Ans: (a)

Sol: E = 1000 W/m^2

AC = 100×100 mm^2 = 10^4 mm^2 = $10^4 \times 10^{-6}$m^2

I_{MPP} = 3A

V_{MPP} = 0.5V

$$P_{max} = I_{MPP}.V_{MPP} = 3\times 0.5 = 1.5\,W$$

$$\eta_{cell} = \frac{P_{max}}{E.A_c} = \frac{1.5}{1000\times 10^{-4}\times 10^{-6}}$$

$$\eta_{cell} = \frac{1.5}{10} = 0.15 = 15\%$$

End of Solution

69. In a barrage of 300000 m^2 area with a tide height of 3 m, barrage drain time of 10 hr, density of seawater as 1025 kg/m^3 and gravitational acceleration as 9.8 m/s^2, the average power will be

(a) 377 kW (b) 381 kW (c) 388 kW (d) 396 kW

69. Ans: (a)

Sol: $E = \frac{1}{2}\rho AgR^2$

$$P_{avg} = \frac{E}{t} = \frac{\frac{1}{2}\times 1025\times 3\times 10^5\times 9.8\times (3)^2}{10\times 3600}\,W$$

$$P_{avg} = 376.7\,kW$$

End of Solution

70. The platinum nano-coating is made on the anode of the fuel cell to

(a) create lighter and more efficient fuel cell membranes

(b) make the fuel effective

(c) create high thermal conductivity in the cell

(d) make the fuel cell non-corrosive

70. Ans: (a)

Sol:

- Platinum is used in fuel cells to catalyse oxygen reduction reaction.
- Platinum nano-coating creates more efficient membranes, which allows to build lighter and longer casting fuel cells.

End of Solution

71. In a fuel cell, electric current is produced when

(a) hydrogen and oxygen react with each other and electrons are freed

(b) hydrogen reacts with water and electrons are freed

(c) oxygen reacts with water and electrons are freed

(d) electrons react with molecules of hydrogen and oxygen is freed

71. Ans: (a)

Sol:

- In fuel cell, hydrogen in the fuel reacts with oxygen in the air which liberates electron and generates electric current.
- H_2O is the by product of the reaction.

End of Solution

72. Which one of the following is suitable for fuel cell electric vehicle (FCEV) ?

(a) Direct methanol fuel cell (DMFC)

(b) Alkaline fuel cell (AFC)

(c) Proton exchange membrane fuel cell (PEMFC)

(d) Solid oxide fuel cell (SOFC)

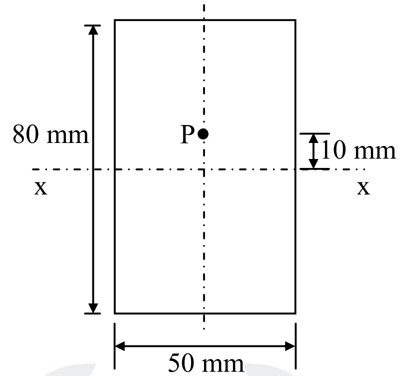
72. Ans: (c)

Sol: PEMFCs are primarily used in transportation application because of their positive potential impact on environment.

For example, control of emission of green house gases.

End of Solution

73. A pull of 100 kN acts on a bar as shown in the figure in such a way that it is parallel to the bar axis and is 10 mm away from xx :



The maximum bending stress produced in the bar at xx is nearly

(a) 20.5 N/mm^2 (b) 18.8 N/mm^2 (c) 16.3 N/mm^2 (d) 14.5 N/mm^2

73. Ans: (b)

Sol: Bending moment, M = 100000×10 = 10^6 N-mm

Maximum bending stress, [At outermost fibre]

$$\sigma_{max} = \frac{M}{I}.y_{max} = \frac{10^6}{\frac{50\times 80^3}{12}}\times 40 = 18.75\,N/mm^2$$

Note: Please read it about xx not as at xx.

End of Solution

74. The frequency of oscillation is the number of cycles per unit time described by the particle, given by the relation

(a) $f = \frac{\omega}{2\pi}$ (b) $\frac{1}{f} = \frac{\omega}{2\pi}$ (c) $f' = \frac{2\pi r}{T}$ (d) $f' = \frac{2\pi NT}{\omega}$

74. Ans: (a)

Sol: f = linear frequency = $\frac{1}{T}$

T = time period of oscillation

ω = circular or angular frequency = angle covered on the phase circle diagram by rotating vector in unit time

= Number of rotations in unit time

$$\omega = \frac{2\pi}{T} = 2\pi f \quad \Rightarrow \quad f = \frac{\omega}{2\pi}$$

75. A particle of mass 1 kg moves in a straight line under the influence of a force which increases linearly with time at the rate of 60 N/s, it being 40 N initially. The position of the particle after a lapse of 5 s, if it started from rest at the origin, will be

(a) 1250 m (b) 1500 m (c) 1750 m (d) 2000 m

75. Ans: (c)

Sol: Given F(t) = 40 + 60t

$M = 1$ kg

Using Newton's II Law,

$$F = ma \Rightarrow a = \frac{F}{m} = 40+60t \text{ m/s}^2$$

But $a = \frac{dv}{dt} \Rightarrow v = \int a\,dt + c_1$ $\quad\because$ it starts initially from rest v = 0 at t = 0 $\Rightarrow c_1 = 0$

$$= \int (40t + 60t)dt$$

$$= 40\,t + 30t^2$$

But $v = \frac{ds}{dt} \Rightarrow s = \int v\,dt + c_2$ $\quad\because$ it starts initially from origin s = 0 at t = 0 $\Rightarrow c_2 = 0$

$$= \int (40\,t + 30t^2)dt$$

$$= 20\,t^2 + 10t^3$$

Position at end of 5^{th} second = s (t = 5)

$$= 20 \times 5^2 + 10 \times 5^3 = 1750 \text{ m}$$

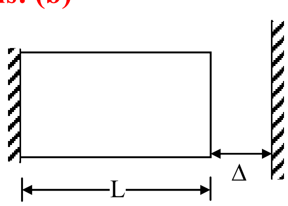
End of Solution

76. Rails are laid such that there will be no stress in them at 24°C. If the rails are 32 m long with an expansion allowance of 8 mm per rail, coefficient of linear expansion $\alpha = 11\times10^{-6}$ /°C and E = 205 GPa, the stress in the rails at 80°C will be nearly

(a) 68 MPa (b) 75 MPa (c) 83 MPa (d) 90 MPa

76. Ans: (b)

Sol:



$L = 32$ m, $\Delta = 8$ mm, $\Delta T = 80 - 24 = 56°C$

$\alpha = 11\times10^{-6} /^0 C$ E = 205 GPa

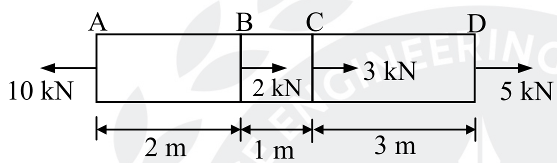
$$(L\alpha\Delta T - 8) = \frac{\sigma L}{E}$$

$$(32\times10^3 \times 11\times10^{-6} \times 56 - 8) = \frac{\sigma\times32\times10^3}{205\times10^3}$$

$\Rightarrow$ $\sigma = 75.03$ MPa

End of Solution

77. The loads acting on a 3 mm diameter bar at different points are as shown in the figure :

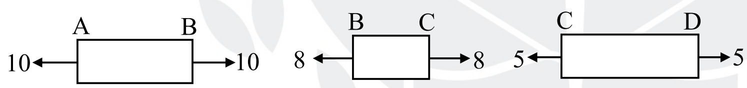


If $E = 205\ GPa$, the total elongation of the bar will be nearly

(a) 29.7 mm (b) 25.6 mm (c) 21.5 mm (d) 17.4 mm

77. Ans: (a)

Sol:



$$\delta L = \delta L_{AB} + \delta L_{BC} + \delta L_{CD}$$

$$\delta L = \frac{[10\times10^3\times2 + (10-2)\times10^3\times1 + 5\times10^3\times3]\times10^3}{205\times10^3\times\frac{\pi}{4}\times3^2}$$

$$\delta L = 29.7\,\text{mm}$$

End of Solution

78. A hollow circular bar used as a beam has its outer diameter thrice the inside diameter. It is subjected to a maximum bending moment of 60 MN-m. If the permissible bending stress is limited to 120 MPa, the inside diameter of the beam will be

(a) 49.2 mm (b) 53.4 mm (c) 57. 6 mm (d) 61.8 mm

78. Ans: (c)

Sol: Bending moment should be in MN-mm

$$\sigma_{max} \le \hat{\sigma}$$

$$\Rightarrow \frac{M}{I} \times y_{max} \le \hat{\sigma}$$

$$\frac{60 \times 10^6 \, Nmm}{\frac{\pi}{64}\left(d_o^4 - d_i^4\right)} \times \frac{d_o}{2} \le 120 \frac{N}{mm^2}$$

$$\Rightarrow \frac{64 \times 60 \times 10^6 \, Nmm}{\pi d_o^4 \left(1 - \frac{1}{81}\right)} \times \frac{d_o}{2} \le 120$$

$$\Rightarrow d_o = 172.76 \, mm$$

$$\Rightarrow d_i = \frac{d_o}{3} = 57.6 \text{ mm}$$

End of Solution

79. In a beam of I-section, which of the following parts will take the maximum shear stress when subjected to traverse loading ?

1. Flange
2. Web

Select the correct answer using the code given below.

(a) 1 only (b) 2 only (c) both 1 and 2 (d) neither 1 nor 2

79. Ans: (b)

Sol: The maximum shear stress is taken by web only.

End of Solution

80. Which of the following statements is/are correct?

1. In uniformly distributed load, the nature of shear force is linear and bending moment is parabolic.
2. In uniformly varying load, the nature of shear force is linear and bending moment is parabolic.
3. Under no loading condition, the nature of shear force is linear and bending moment is constant.

Select the correct answer using the code given below.

(a) 1 and 2 (b) 1 and 3 (c) 2 only (d) 1 only

80. Ans: (d)

Sol: In UDL, shear force is linear and bending moment is parabolic.

$\Rightarrow$ statement 1 is correct.

In UVL, shear force is parabolic and bending moment is cubic.

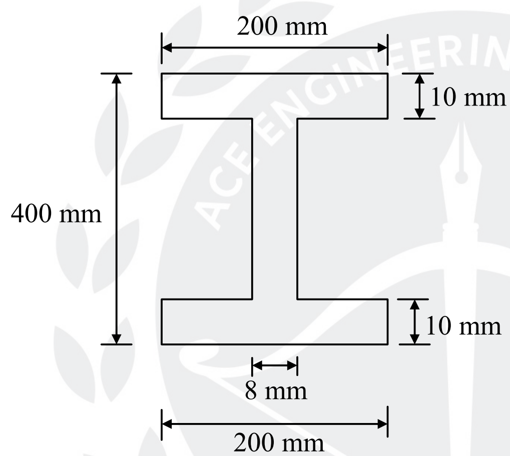
$\Rightarrow$ statement 2 is incorrect.

In no loading, shear force is constant and bending moment is linear.

$\Rightarrow$ Therefore, statement 3 is incorrect.

End of Solution

81. The cross-section of the beam is as shown in the figure:



If the permissible stress is 150 N/mm^2, the bending moment M will be nearly

(a) 1.21×10^8 N mm
(b) 1.42×10^8 N mm
(c) 1.64×10^8 N mm
(d) 1.88×10^8 N mm

81. Ans: (b)

Sol: $\hat{M} = \hat{\sigma}.z = \hat{\sigma}\left(\dfrac{I}{y_{max}}\right)$

$$\Rightarrow \hat{M} = 150\times\frac{\left[\dfrac{200\times400^3}{12} - 2\times\dfrac{96\times380^3}{12}\right]}{200}$$

$$\Rightarrow \hat{M} = 1.42\times10^8\,\text{Nmm}$$

End of Solution

82. In a propeller shaft, sometimes apart from bending and twisting, end thrust will also develop stresses which would be

(a) tensile in nature and uniform over the cross-section.
(b) compressive in nature and uniform over the cross-section.
(c) tensile in nature and non-uniform over the cross-section.
(d) compressive in nature and non-uniform over the cross-section.

82. Ans: (b)

Sol: Due to end thrust, stresses would be compressive in nature and uniform over cross section.

End of Solution

83. A spherical shell of 1.2 m internal diameter and 6 mm thickness is filled with water under pressure until volume is increased by 400×10^3 mm^3. If E = 204 GPa, Poisson's ratio ν = 0.3, neglecting radial stresses, the hoop stress developed in the shell will be nearly

(a) 43 MPa (b) 38 MPa (c) 33 MPa (d) 28 MPa

83. Ans: (a)

Sol: Volumetric strain of a spherical shell is given as, $\epsilon_V = 3\epsilon_c$

$$\Rightarrow \frac{\delta V}{V} = 3\frac{\sigma(1-\nu)}{E} \Rightarrow \sigma = \frac{E\times\delta V}{V\times3(1-\nu)}$$

$$\Rightarrow \sigma = \frac{204\times10^3\times400\times10^3}{\frac{\pi}{6}\times(1.2\times10^3)^3\times3\times(1-0.3)} = 42.94\,\text{MPa}$$

End of Solution

84. The inner diameter of a cylindrical tank for liquefied gas is 250 mm. The gas pressure is limited to 15 MPa. The tank is made of plain carbon steel with ultimate tensile strength of 340 N/mm^2, Poisson's ratio of 0.27 and the factor of safety of 5. The thickness of the cylinder wall will be

(a) 60 mm (b) 50 mm (c) 40 mm (d) 30 mm

84. Ans: (d)

Sol: $\sigma_{max} \le \hat{\sigma} \Rightarrow \frac{pd}{2t} \le \frac{\sigma_{ultimate}}{FOS}$

$$\Rightarrow \frac{15\times250}{2t} \le \frac{340}{5} \Rightarrow t \ge 27.57\,\text{mm}$$

The nearest greater value of the thickness is 30 mm.

85. The structure of sodium chloride is considered as

(a) a body-centered crystal

(b) a simple cubic crystal

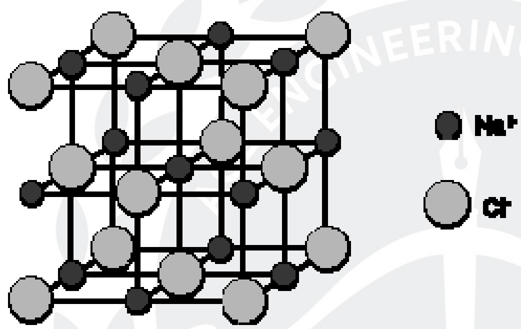
(c) two interpenetrating FCC sub-lattices of Cl^- ions and Na^+ ions

(d) a cubic crystal with Na^+ and Cl^- alternatively at the cubic corners

85. Ans: (c)

Sol: The structure of sodium chloride:

It is a face centred cubic lattice with two atom basis (or) as two interpenetrating face centred cubic lattices.



End of Solution

86. Hardenability of steel is assessed by

(a) Charpy impact test

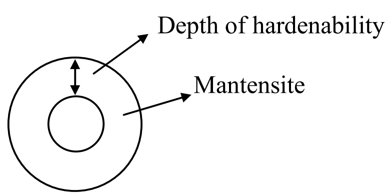
(b) Rockwell hardness test

(c) Jominy end-quench test

(d) Open-hole test

86. Ans: (c)

Sol: **Hardenability:** It is the depth from the surface of material upto which martensite is present.



Depth of hardenability is measured by jominy end quench test.

End of Solution

87. A metal has lattice parameter of 2.9 $\overset{o}{A}$, density of 7.87 g/cc, atomic weight of 55.85 and Avogadro's number is 6.0238×10^{23}. The number of atoms per unit cell will be nearly

(a) 1 (b) 2 (c) 8 (d) 16

87. Ans: (b)

Sol: $a = 2.9A° = 2.9\times10^{-8}$ cm

Atomic weight (A) = 55.85

Avogadro's number (N_A) = 6.023×10^{23} g/mole

Density (ρ) = 7.87 g/cc

$$\rho = \frac{nA}{AN\times V_{vc}}$$

$$n = \frac{\rho\times AN\times V_{vc}}{A}$$

$$= \frac{7.87\times6.023\times10^{23}\times\left(2.9\times10^{-8}\right)^3}{55.85} = 2.069\approx 2$$

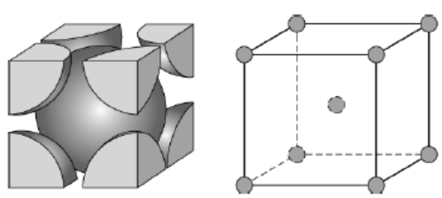
End of Solution

88. An atomic packing factor (APF) for the BCC unit cell of hard spheres atoms will be

(a) 0.63 (b) 0.68 (c) 0.73 (d) 0.78

88. Ans: (b)

Sol: Body centred cubic structure (BCC):



- In this structure the eight corners of the cube are occupied by eight atoms and the center of the cube is occupied by one atom.

  Ex: Chromium (Cr), Tungsten (W), Alfa-Iron (α-Fe), Vanadium (V), Sodium (Na)

- Effective number of atoms in the unit cell of BCC structure:

$$= 8\times\frac{1}{8}+1 = 2\,\text{atom}$$

- Relation between lattice constant and radius of atoms:

  Consider cubic diagonal

$$4r = a\sqrt{3} \Rightarrow r = \frac{a\sqrt{3}}{4}$$

$$APF = \frac{2 \times \frac{4}{3}\pi r^3}{a^3} = 0.68$$

89. The distinct characteristic of Invar is

(a) it is magnetic

(b) it has low coefficient of thermal expansion

(c) it has high tensile strength

(d) it is non-corrosive

89. Ans: (b)

Sol: **Invar:** It is an alloy of Iron and Nickel with a negligible coefficient of expansion, used in making scientific instruments.

End of Solution

90. An alloy produced by adding 1% of tin to Muntz metal is called as

(a) a brass (b) Admiralty brass

(c) Naval brass (d) Leaded brass

90. Ans: (c)

Sol: Some common Brass alloys are

1. Naval Brass = 60% Cu, 39% Zn, 1% Tin
2. Muntz metal = 60% Cu, 40% Zn
3. Admiralty brass = 70% Cu, 29% Zn, 1% Tin

End of Solution

91. A sample of glass has a crack of half-length 2 μm. The Young's modulus of glass is 70 GN/m^2 and specific surface energy is 1 J/m^2. The fracture strength will be

(a) 885 MPa (b) 895 MPa (c) 915 MPa (d) 935 MPa

91. Ans: (*)

Sol: The fracture strength (σ_f) is given by

$$\sigma_f = \sqrt{\frac{2E\gamma}{\pi a}} = \sqrt{\frac{2 \times 70 \times 10^9 \times 1}{\pi \times 2 \times 10^{-6}}} = 149.2 \text{ MPa}$$

92. In the Pb-Sn system, the fraction of total α phase is 3 times the fraction of β phase at eutectic temperature of 182°C, Pb with 19% Sn dissolved in it, Sn with 2.5% Pb dissolved in it, and liquid is in equilibrium. The alloy compositions of tin (Sn) and lead (Pb) are nearly

(a) 28.6 % and 71.4 % (b) 38.6 % and 61.4 %

(c) 48.6 % and 51.4 % (d) 58.6 % and 41.4 %

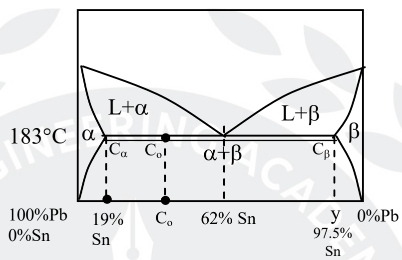
92. Ans: (b)

Sol: Pb-Sn system

$m_{total-\alpha} = 3m_{total-\beta}$ at 182°C

C_α = 19% Sn

C_β = 2.5% Pb = 97.5% Sn



$$m_\alpha = \frac{C_\beta - C_o}{C_\beta - C_\alpha}$$

$$m_\beta = \frac{C_o - C_\alpha}{C_\beta - C_\alpha}$$

$$\frac{97.5 - C_o}{C_\beta - C_\alpha} = 3\left(\frac{C_o - 19\%}{C_\beta - C_\alpha}\right)$$

$97.5 - C_o = 3C_o - 57$

$4C_o = 154.5$

$C_o = 38.6$ % Sn

Tin (Sn) = 38.6%

Lead (Pb) = 61.4%

End of Solution

93. A cylindrical specimen of steel having an original diameter of 12.8 mm is tensile tested to fracture and found to have engineering fracture strength σ_f of 460 MPa. If its cross-sectional diameter at fracture is 10.7 mm, the true stress at fracture will be

(a) 660 MPa (b) 645 MPa (c) 630 MPa (d) 615 MPa

93. Ans: (a)

Sol: Engineering stress (S) = 460 MPa

Initial cross sectional area (A_o) = 12.8 mm

Instantaneous area (A) = 10.7 mm

Load, (F) = S×A$_o$ = $460 \times \frac{\pi}{4} \times 12.8^2$

$$\text{True stress} = \frac{F}{A} = \frac{460 \times \frac{\pi}{4} \times 12.8^2}{\frac{\pi}{4} \times 10.7^2} = 658.27 = 660 \text{ MPa}$$

End of Solution

94. An iron container 10 cm × 10 cm at the base is filled to a height of 20 cm with a corrosive liquid. A current is produced as a result of an electrolytic cell, and after four weeks, the container has decreased in weight by 70 g. If $n = 2$, $F = 96500$ C and $M = 55.84$ g/mole, the current will be

(a) 0.05 A (b) 0.10 A (c) 0.20 A (d) 0.40 A

94. Ans: (b)

Sol: $\text{MRR} = \frac{70}{4 \times 7 \times 24 \times 3600} \text{ g/sec}$

F = 96500

A = M = 55.84

Z = n = 2

I = current

$$\text{MRR} = \frac{AI}{ZF}$$

$$I = \frac{\text{MRR} \times ZF}{A} = 70 \times \frac{2 \times 96500}{4 \times 7 \times 24 \times 3600 \times 54.84} = 0.1 \text{ A}$$

95. A copper piece originally 305 mm long is pulled in tension with a stress of 276 MPa. If the deformation is entirely elastic and the modulus of elasticity is 110 GPa, the resultant elongation will be nearly

(a) 0.43 mm (b) 0.54 mm (c) 0.65 mm (d) 0.77 mm

95. Ans: (d)

Sol: $\delta\ell = \frac{P\ell}{AE} = \frac{\sigma\ell}{E} = \frac{276 \times 305}{110 \times 10^3} = 0.765 \text{ mm}$

End of Solution

96. The indentation on a steel sample has been taken using 10 mm tungsten carbide ball at 500 kgf load. If the average diameter of the indentation is 2.5 mm, the BHN will be nearly

(a) 90 (b) 100 (c) 110 (d) 120

96. Ans: (b)

Sol: $$\text{BHN} = \frac{2P}{\pi D\left[D - \sqrt{D^2 - d^2}\right]}$$

$$= \frac{2 \times 500}{\pi \times 10\left[10 - \sqrt{10^2 - 2.5^2}\right]} = 100.242 \text{ kgf/mm}^2$$

End of Solution

97. Which of the following statements are correct with respect to inversion of mechanism?

1. It is a method of obtaining different mechanism by fixing different links of the same kinematic chain.
2. It is a method of obtaining different mechanisms by fixing the same links of different kinematic chains.
3. In the process of inversion, the relative motions of the links of the mechanism produced remain unchanged.
4. In the process of inversion, the relative motions of the links of the mechanisms produced will change accordingly.

Select the correct answer using the code given below.

(a) 1 and 3 (b) 1 and 4 (c) 2 and 3 (d) 2 and 4

97. Ans: (a)

Sol: Inversion is the process of alternately fixing each link of a kinematic chain to get different types of mechanisms where the relative motion between links remain unchanged but the absolute motion between them gets inverted i.e., the sense of their motion changes from clockwise to counter-clock wise rotation or from rightward movement to leftward.

End of Solution

98. For the follower with stroke *S*, following the cycloidal motion, the radium of the rolling circle will be

(a) $S \times 2\pi$ (b) $\frac{S}{2\pi}$ (c) $\frac{2\pi}{S}$ (d) $S + 2\pi$

98. Ans: (b)

Sol: Total rise for cycloidal motion (lift of the follower)

Stroke = S = 2πR

where, R = radius of cycloid generating circle

$\therefore \quad R = \dfrac{S}{2\pi}$

End of Solution

99. A vertical shaft of 100 mm diameter and 1 m length has its upper end fixed at the top. The other end carries a disc of 5000 N and the modulus of elasticity of the shaft material is 2×10^5 N/mm^2. Neglecting the weight of the shaft, the frequency of the longitudinal vibrations will be nearly

(a) 279.5 Hz (b) 266.5 Hz (c) 253.5 Hz (d) 241.5 Hz

99. Ans: (a)

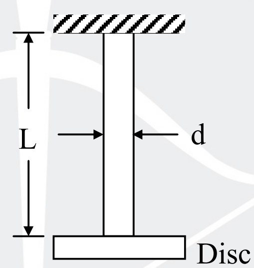
Sol: d = 100 mm = 0.1 m

L = 1m

$E = 2\times10^5$ N/mm^2 $= 2\times10^{11}$ N/m^2

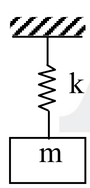
A = c/s area

$= \dfrac{\pi}{4}d^2 = 0.007854\,m^2$



Disc mass, $m = \dfrac{5000}{9.81} = 509.7\,kg$

The system can be simplified as simple spring mass system (neglecting mass of shaft)



Where shaft is replaced by a simple spring of stiffness, $k = \dfrac{EA}{L}$

∴ Natural frequency of longitudinal vibration

$$f = \frac{1}{2\pi}\sqrt{\frac{k}{m}} = \frac{1}{2\pi}\sqrt{\frac{EA}{L\,m}}\ \text{Hz}$$

$$= \frac{1}{2\pi}\sqrt{\frac{2\times10^{11}\times0.007854}{1\times509.7}} = 279.4\ \text{Hz}$$

End of Solution

100. The accurate method of finding the natural frequency of transverse vibrations of a system of several loads attached to some shaft is

(a) Dunkerley method (b) Energy method

(c) Stodola method (d) Dunkerley and energy method

100. Ans: (b)

End of Solution

101. The speed of which the shaft runs, so that the deflection of the shaft from the axis of rotation becomes infinite, is known as

(a) whipping speed (b) damping speed

(c) resonant speed (d) gravitational speed

101. Ans: (a)

End of Solution

102. Which one of the following is **not** the correct statement with respect to the involute profile toothed gears in mesh?

(a) Pressure angle remains constant from the start till the end of the engagement.

(b) The base circle diameter and the pitch circle diameter of the two mating involutes are proportional.

(c) When two involutes are in mesh, the angular velocity ratio is proportional to the size of the base circles.

(d) The shape of the involute profile depends only on the dimensions of the base circle.

102. Ans: (c)

Sol: Angular velocity ratio is constant and not proportional to base circle size.

End of Solution

103. The centre distance C between two gears, in terms of base circle radii R_1, R_2 and the pressure angle ϕ, is

(a) $\dfrac{\cos\phi}{R_1 + R_2}$ (b) $\dfrac{R_1 + R_2}{\cos\phi}$

(c) $\left(\dfrac{R_1}{R_2}\right)\cos\phi$ (d) $\left(\dfrac{R_2}{R_1}\right)\cos\phi$

103. Ans: (b)

Sol: For involute gears

$$r_b = r \cos \phi$$

r_b = Base circle radius

r = pitch circle radius

ϕ = pressure angle

Center distance C = sum of pitch circle radii of two meshing gears

$$= \frac{\text{sum of base circle radii}}{\cos\phi}$$

$$= \frac{R_1 + R_2}{\cos\phi}$$

End of Solution

104. A three-cylinder single-acting engine has its cranks at 120°. The turning moment diagram for each cycle is a triangle for the power stroke with a maximum torque of 60 N m at 60° after the dead centre of the corresponding crank. There is no torque on the return stroke. The engine runs at 400 r.p.m. The power developed will be

(a) 1745 W (b) 1885 W (c) 1935 W (d) 1995 W

104. Ans: (b)

Sol: Energy produced in one cycle per cylinder = Area of turning moment diagram

$$= \frac{1}{2} \times \pi \times 60 = 30\pi \text{ Joule}$$

(π = angle turned by crank during power stroke)

Total energy produced by 3 cylinders = 90 πJ

$$\text{Mean torque} = \frac{\text{Total energy produced per cycle}}{\text{Angle rotated by crank per cycle}}$$

$$T_{mean} = \frac{90\pi}{2\pi} = 45\,\text{Nm}$$

Given N_{mean} = 400 rpm

Power produced = $T_{maen}\, \omega_{mean}$

$$= 45 \times \frac{2\pi \times 400}{60} = 1885\,\text{W}$$

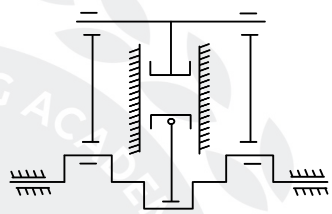
End of Solution

105. A vertical single-cylinder opposed piston type engine has reciprocating parts of mass 2000 kg for the lower piston and 2750 kg for the upper piston. The lower piston has a stroke of 60 cm and the engine is in primary balance. If the ratio of the legnth of connecting rod to crank is 4 for the lower piston and 8 for the upper piston, and when the crankshaft speed is of 135 r.p.m., the maximum secondary unbalanced force will be

(a) 48935.5 N (b) 46946.5 N (c) 44968.5 N (d) 42989.5 N

105. Ans: (c)

Sol: $n_\ell = \left(\frac{\ell}{r}\right)_{lower} = 4$ $\quad n_u = \left(\frac{\ell}{r}\right)_{upper} = 8$



[r = crank radius, *l* = connecting rod length]

Given,

$m_l = 2000$ kg

$m_u = 2750$ kg

s_l = stroke of lower piston = 60 cm = $(2r)_{lower}$

$\omega = 135 \text{ rpm} = \frac{2\pi}{60} \times 135 = 14.14$ rad/s

$r_{lower} = \frac{s_\ell}{2} = 30\,\text{cm}$

Referring to the figure,

if θ is orientation of crank connected to lower piston then θ+π is the orientation of crank connected to upper piston.

For primary balance, the primary unbalanced forces of both pistons should nullify when summed up

$\Rightarrow F_\ell^P + F_u^P = 0$

$\Rightarrow m_\ell r_\ell \omega^2 \cos\theta + m_u r_u \omega^2 \cos(\theta + \pi) = 0$

$\Rightarrow m_\ell r_\ell = m_u r_u \Rightarrow r_u = \frac{m_\ell}{m_u} r_\ell = \frac{2000}{2750} \times 30 = 21.818\,\text{cm}$

F_s = Secondary unbalanced force = $F_\ell^S + F_u^S = \frac{m_\ell r_\ell \omega^2 \cos(2\theta)}{n_\ell} + \frac{m_u r_u \omega^2 \cos(2\theta + 2\pi)}{n_u}$

$$(F^s)_{max} = \left(\frac{m_\ell r_\ell}{n_\ell} + \frac{m_u r_u}{n_u}\right)\omega^2$$

$$= \left(\frac{2000 \times 0.3}{4} + \frac{2750 \times 0.2182}{8}\right) \times 14.14^2 = 44987.66\text{ N}$$

106. The reciprocating mass is balanced when primary force is

1. balanced by the mass = $cmr\omega^2 \cos\theta$
2. unbalanced by the mass = $cmr\omega^2 \cos\theta$
3. balanced by the mass = $(1 - c)cmr\omega^2 \cos\theta$
4. unbalanced by the mass = $(1 - c)cmr\omega^2 \cos\theta$

Select the correct answer using the code given below.

(a) 1 and 3 (b) 2 and 3 (c) 1 and 4 (d) 2 and 4

106. Ans: (c)

Sol: Unbalanced by the mass = $(1 - c)$ '**c**' $mr\omega^2 \cos\theta$ $\Rightarrow$ ***c*** *is the printing mistake*

End of Solution

107. The active gyroscopic torque in gyroscope about a horizontal axis represents

(a) the torque required to cause the axis of spin to precess in the vertical plane.

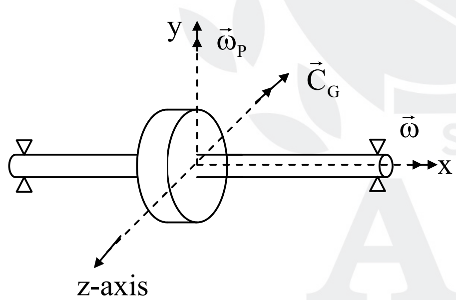
(b) the torque required to cause the axis of spin to precess in the horizontal plane.

(c) the force required to cause the axis of spin to precess in the horizontal plane.

(d) the force required to cause the axis of spin to precess in the vertical plane.

107. Ans: (b)

Sol:



y-axis (axis of precession)

x-axis (axis of spin)

C_G = Active gyroscopic couple (horizontal)

xz plane $\rightarrow$ plane of precession (horizontal plane)

End of Solution

108. The change in governor height for a Watt governor when speed varies from 100 r.p.m to 101 r.p.m will be nearly

(a) 1.8 mm (b) 2.6 mm (c) 3.4 mm (d) 4.2 mm

108. Ans: (a)

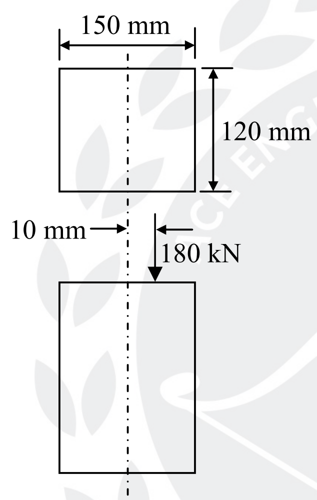
Sol: h = height of Watt's governor = $\dfrac{895000}{N^2}$ mm

$$\Delta h = h_1 - h_2 = \frac{895000}{N_1^2} - \frac{895000}{N_2^2} = 895000\left[\frac{1}{100^2} - \frac{1}{101^2}\right]$$

$$= 1.76 \text{ mm} \cong 1.8 \text{ mm}$$

End of Solution

109. A rectangular strut is 150 mm wide and 120 mm thick. It carries a load of 180 kN at an eccentricity of 10 mm in a plane bisecting the thickness as shown in the figure:



The maximum intensity of stress in the section will be

(a) 14 MPa (b) 12 MPa (c) 10 MPa (d) 8 MPa

109. Ans: (a)

Sol: P = 180 kN, b = 150 mm, d = 120 mm, e = 10 mm

$$\sigma_{max} = \frac{P}{A} + \frac{P.e}{\dfrac{db^2}{6}}$$

$$= \frac{P}{b.d}\left[1 + \frac{6e}{b}\right]$$

$$= \frac{180\times10^3}{150\times120}\left[1 + \frac{6\times10}{150}\right]$$

$$\sigma_{max} = 14\,\text{MPa}$$

End of Solution

110. The theory of failure used in designing the ductile materials in a most accurate way is by

1. maximum principal stress theory
2. distortion energy theory
3. maximum strain theory

Select the correct answer using the code given below.

(a) 1, 2 and 3 (b) 1 only (c) 2 only (d) 3 only

110. Ans: (c)

Sol: Since ductile materials, under static conditions, mostly fail due to shear or distortion, distortion energy theory produces most accurate results.

End of Solution

111. When a load of 20 kN is gradually applied at a particular point in a beam, it produces a maximum bending stress of 20 MPa and a deflection of 10 mm. What will be the height from which a load of 5 kN should fall onto the beam at the same point if the maximum bending stress is 40 MPa?

(a) 80 mm (b) 70 mm (c) 60 mm (d) 80 mm

111. Ans: (c)

Sol: Given data :

Static load, $P_{s1} = 20$ kN, $P_{s2} = 5$ kN

Static deflection, $\delta_{s1} = 10$ mm, $\sigma_{s1} = 20$ MPa,

$$\frac{\delta_{s2}}{\delta_{s1}} = \frac{P_{s2}}{P_{s1}}$$

$$\delta_{s2} = 10 \times \frac{5}{20} = 2.5 \text{ mm}$$

$$\frac{\sigma_{s2}}{\sigma_{s1}} = \frac{P_{s2}}{P_{s1}}$$

$$\sigma_{s2} = 20 \times \frac{5}{20} = 5 \,\text{MPa}$$

The impact stress (σ_{i2}) when 5 kN load is dropped from height 'h' is given by,

$$\frac{\sigma_{i2}}{\sigma_{s2}} = 1 + \sqrt{1 + \frac{2h}{\delta_{s2}}}$$

$$\frac{40}{5} = \left(1 + \sqrt{1 + \frac{2h}{2.5}}\right) \Rightarrow h = 60 \text{ mm}$$

112. The areas of fatigue failure in a part may be in the

1. region having slow growth of crack with a fine fibrous appearance.
2. region having faster growth of crack with a fine fibrous appearance.
3. region of sudden fracture with a coarse granular appearance.
4. region of gradual fracture with a coarse granular appearance.

Select the correct answer using the code given below:

(a) 2 and 3 (b) 2 and 4 (c) 1 and 4 (d) 1 and 3

112. Ans: (d)

Sol: Fatigue failure is recognized through

(i) crack having fine fibrous appearance associated with slow growth rate and

(ii) crack having coarse granular appearance associated with faster growth rate.

End of Solution

113. The shock-absorbing capacity (resilence) of bolts can be increased by

(a) increasing the shank diameter above the core diameter of threads
(b) reducing the shank diameter to the core diameter of threads
(c) decreasing the length of shank portion of the bolt
(d) pre-heating of the shank portion of the bolt

113. Ans: (b)

Sol: The shock absorbing capacity of bolts can be increased by reducing the shank diameter of bolt to the core diameter of threads.

End of Solution

114. The torque required to tighten the bolt comprises of the

(a) torque required in overcoming thread friction only
(b) torque required in inducing the pre-load only
(c) torque required in overcoming circumferential hoop stress
(d) torque required in overcoming thread friction and inducing the pre-load and also the torque required to overcome collar friction between the nut and the washer.

114. Ans: (d)

Sol: The torque required to tighten a bolt comprises of

- the part required to overcome thread friction
- the part required to induce preload or pretension in the bolt and
- the part required to overcome collar friction between the nut and the washer

115. A steel spindle transmits 4 kW at 800 r.p.m. The angular deflection should not exceed 0.25°/m length of the spindle. If the modulus of rigidity for the material of the spindle is 84 GPa, the diameter of the spindle will be

(a) 46 mm (b) 42 mm (c) 38 mm (d) 34 mm

115. Ans: (d)

Sol: P = 4 kW, N = 800 rpm, G = 84 GPa ,

$\theta = 0.25°/\text{m} = 0.25\times\frac{\pi}{180}\times\frac{1}{1000}\text{rad/mm}$, d = ?

$$T = \frac{60P}{2\pi N} = \frac{60\times 4\times 10^3}{2\pi\times 800} = 47.75 \text{ N-m}$$

$$\frac{\theta}{L} = \frac{T}{GJ}$$

$$0.25\times\frac{\pi}{180}\times\frac{1}{1000} = \frac{47.75\times 10^3}{84\times 10^3\times J}$$

$$\frac{\pi}{32}.d^4 = J = 130.28\times 1000$$

$\Rightarrow$ d = 33.9 mm

End of Solution

116. A taper roller bearing has a dynamic load capacity of 26 kN. The desired life for 90% of the bearings is 8000 hr and the speed is 300 r.p.m. The equivalent radial load that the bearing can carry will be nearly

(a) 5854 N (b) 5645 N (c) 5436 N (d) 5227 N

116. Ans: (a)

Sol: c = 26 kN, $L_{10h} = 8000\text{ hr}$, n = 300 rpm

Bearing life (L_{10}) $= \frac{60nL_{10h}}{10^6} = \frac{60\times 300\times 8000}{10^6} = 144 \text{ million rev}$

Equivalent radial load

$$P = \frac{c}{(L_{10})^{0.3}} = \frac{26000}{(144)^{0.3}} = 5854.16 \text{ N}$$

Since the bearing is to carry purely radial load, $F_r = P = 5854.16\text{ N}$

End of Solution

117. Hollow shafts are stronger than solid shafts having same weight because

(a) the stiffness of hollow shaft is less than that of solid shaft.

(b) the strength of hollow shaft is more than that of solid shaft.

(c) the natural frequency of hollow shaft is less than that of solid shaft.

(d) in hollow shafts, material is not spread at large radius.

117. Ans: (b)

Sol: Strength of hollow shaft is more than that of solid shaft because polar section modulus of hollow shaft is greater than that of solid shaft.

End of Solution

118. A propeller shaft is required to transmit 45 kW power at 500 r.p.m. It is hollow shaft having inside diameter 0.6 times the outside diameter. It is made of plain carbon steel and the permissible shear stress is 84 N/mm^2. The inner and outer diameters of the shaft are nearly

(a) 21.7 mm and 39.1 mm

(b) 23.5 mm and 39.1 mm

(c) 21.7 mm and 32.2 mm

(d) 23.5 mm and 32.2 mm

118. Ans: (b)

Sol: $$T = \frac{60P}{2\pi N} = \frac{60\times 45\times 10^3}{2\pi\times 500} = 859.4\,\text{Nm}$$

$$Z_{max} = \frac{16T}{\pi D_o^3\left(1-k^4\right)}$$

$$84 = \frac{16\times 859.4\times 10^3}{\pi D_o^3\left[1-(0.6)^4\right]}$$

$D_o = 39.1$ mm

$D_i = 0.56\times 39.1 = 23.47$ mm

End of Solution

119. A bicycle and rider travelling at 12 km/hr on a level road have a mass of 105 kg. A brake is applied to a rear wheel having 800 mm diameter. The pressure on the brake is 80 N and the coefficient of friction is 0.06. The number of turns of the wheel before coming to rest will be

(a) 48.3 revolutions (b) 42.6 revolutions

(c) 38.3 revolutions (d) 32.6 revolutions

119. Ans: (a)

Sol: Initial angular velocity, $\omega_0 = \frac{V}{r}$

where,

$$V = \frac{12 \times 1000}{3600} = 3.33\,\text{m/s}$$

$$r = \frac{800}{1000 \times 2} = 0.4\,\text{m}$$

$$\omega_0 = \frac{3.33}{0.4} = 8.33\,\text{rad/s}$$

$$\alpha = \frac{\text{Torque}}{\text{Moment of inertia}} = \frac{80 \times 0.06 \times 0.4}{105 \times 0.4^2} = 0.114\ \text{rad/s}^2$$

$$\omega^2 = \omega_0^2 - 2\alpha\theta$$

$$0 = 8.33^2 - 2\times 0.114 \times \theta$$

$$\theta = 304.33\ \text{rad}$$

$$\text{Total revolutions} = \frac{304.33}{2\pi} = 48.4\ \text{revolution}$$

End of Solution

120. The avoid self-engagement in cone clutch, tis semi-cone angle is always kept

(a) smaller than the angle of static friction

(b) equal to the angle of static friciton

(c) greater than the angle of static friction

(d) half of the angle of static friction

120. Ans: (c)

Sol: To avoid self engagement in cone clutch, the semi cone angle should always be kept greater than the angle of static friction.

End of Solution

121. In case of arc welding of steel with a potential of 20 V and current of 200 A, the trave speed is 5 mm/s and the cross-sectional area of the joint is 20 mm^2. The heat required for melting steel may be taken as 10 J/mm^3 and heat transfer efficiency as 0.85. The melting efficiency will be nearly.

(a) 18 % (b) 29 %

(c) 36 % (d) 42 %

121. Ans: (b)

Sol: $V = 20$ V, $I = 200$ A, Speed = 5 mm/s

$A_w = 20$ mm^2, H.R/mm^3 = 10 J/mm^3

$\eta_{H.T} = 0.85$

Melting rate of weld bead = $A_w \times$ Speed

$= 20 \times 5 = 100$ mm^3/s

Rate of H.R for melting = melting rate × H.R/mm^3

$= 100 \times 10 = 1000$ J/sec

Heat generated = $V \times I = 20 \times 200 = 4000$ J/s

Rate of Heat input = $0.85 \times 4000 = 3400$ J/s

$$\eta_{\text{melting}} = \frac{1000}{3400} = 0.2941 = 29.41\%$$

End of Solution

122. What is the force required for 90° bending of St50 steel of 2 mm thickness in a V-die, if the die opening is taken as 8 times the thickness and the length of the bent part is 1 m, ultimate tensile strength is 500 MPa and K = 1.33?

(a) 166.25 kN (b) 155.45 kN (c) 154.65 kN (d) 143.85 kN

122. Ans: (a)

Sol: $K = 1.33$, $t = 2$ mm, $w = 8t$

$L = 1$ m, $\sigma_u = 500$ MPa,

$$\text{Force required for bending} = \frac{KLt^2\sigma_u}{w} = \frac{1.33 \times 1000 \times 2^2 \times 500}{8 \times 2} = 166.25 \text{ kN}$$

End of Solution

123. A graph is drawn to a vertical magnification of 10000 and horizontal magnification of 100, and the areas above and below the datum line are as follows:

Above	150 mm^2	80 mm^2	170 mm^2	40 mm^2
Below	80 mm^2	60 mm^2	150 mm^2	120 mm^2

The average roughness R_a for sampling length of 0.8 mm will be

(a) 1.14 μm (b) 1.10 μm (c) 1.06 μm (d) 1.02 μm

123. Ans: (c)

Sol: $\sum A = 150 + 80 + 170 + 40 + 80 + 60 + 150 + 120 = 850 \text{ mm}^2$

$L = 0.8$ mm,

H.M = 100, V.M = 10000

$$R_a = \frac{\sum A}{L} \times \frac{1000}{V.M} \times \frac{1}{H.M}$$

$$= \frac{850}{0.8} \times \frac{1000}{10000} \times \frac{1}{100} = 1.06 \ \mu\text{m}$$

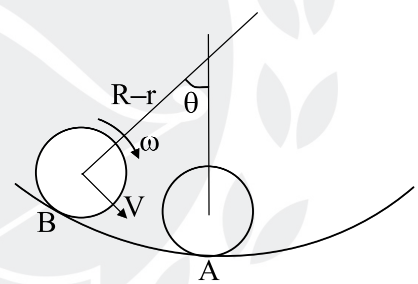
End of Solution

124. The radius of arc is measured by allowing a 20 mm diameter roller to oscillate to and fro on it and the time for 25 oscillations is noted at 56.25 s. The radius of arc will be

(a) 865 mm (b) 850 mm (c) 835 mm (d) 820 mm

124. Ans: (b)

Sol: $V = \omega r = (R - r)\dfrac{d\theta}{dt}$ -------(i)



Total mechanical energy at position 'B' gives

$$E = mg(R-r)(1-\cos\theta) + \frac{1}{2}I\omega^2 + \frac{1}{2}mv^2$$

$$I = \frac{1}{2}mr^2$$

Using (i)

$$E = mg(R-r)(1-\cos\theta) + \frac{1}{2}\times\frac{1}{2}mr^2\times\left(\frac{R-r}{r}\right)^2\left(\frac{d\theta}{dt}\right)^2 + \frac{1}{2}m\times(R-r)^2\left(\frac{d\theta}{dt}\right)^2$$

Differentiating with respect to time.

We get, $$\frac{d^2\theta}{dt^2} = -\frac{2g}{3(R-r)}\theta$$

$$\omega_n = \sqrt{\frac{2g}{3(R-r)}}$$

$$T = 2\pi\sqrt{\frac{3(R-r)}{2g}}$$

$$\frac{56.25}{25} = 2\pi\sqrt{\frac{3(R-0.01)}{2\times 9.81}} \Rightarrow R = 848.8 \text{ mm} \approx 850 \text{ mm}$$

End of Solution

125. Which one of the following systems is consisting of processing stations, material handling and storage, computer control system and human labour?

(a) Portable manufacturing system

(b) Focused integrated system

(c) Flexible manufacturing system

(d) Automated integrated system

125. Ans: (c)

Sol: From the given options FMS only consists of processing stations (M/C's) automated guided vehicle (AGV), computer control system (Host computer) and human labour for loading and unloading.

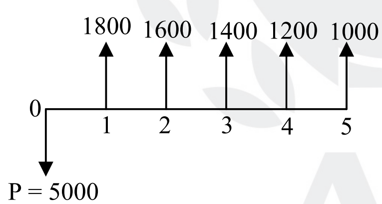
End of Solution

126. A project initially costs ₹ 5,000 and generates year-end cash inflows of ₹ 1800, ₹ 1600, ₹ 1400, ₹ 1200 and ₹ 1000 respectively in five years of its life. If the rate or return is 10%, the net present value (NPV) will be

(a) ₹ 500 (b) ₹ 450 (c) ₹ 400 (d) ₹ 350

126. Ans: (b)

Sol:



Rate of return (i) = 10 %

$$NPV = -5000 + \frac{1800}{(1+0.1)^1} + \frac{1600}{(1+0.1)^2} + \frac{1400}{(1+0.1)^3} + \frac{1200}{(1+0.1)^4} + \frac{1000}{(1+0.1)^5}$$

$= -5000 + 1800 \times 0.909 + 1600 \times 0.826 + 1400 \times 0.751 + 1200 \times 0.682 + 1000 \times 0.620$

$= -5000 + 1636.2 + 1321.6 + 1051.4 + 818.4 + 620$

$= 447.6 \approx$ ₹ 450

End of Solution

127. What is the mode for the following distribution ?

Gross profit as percentage of sales	*Number of companies*
0 – 7	19
7 – 14	25
14 – 21	36
21 – 28	72
28 – 35	51
35 – 42	43
42 – 49	28

(a) 19.55 (b) 21.40 (c) 23.25 (d) 25.10

127. Ans: (d)

Sol: Frequency of model class (f_0) = 72 (highest frequency among all the frequencies)

Frequency preceding to model class (f_1) = 36

Frequency next to model class (f_2) = 51

Lower limit of model class (L) = 21

Width of model class (h) = 28 – 21 = 7

$$\text{Mode} = L + \left(\frac{f_0 - f_1}{2f_0 - f_1 - f_2}\right) \times h$$

$$= 21 + \left(\frac{72 - 36}{2 \times 76 - 36 - 51}\right) \times 7$$

= 21 + 4.42 = 25.42

End of Solution

128. Consider the following data for quality acceptance process:

$N = 10000$

$n = 89$

$c = 2$

$p = 0.01$ (incoming lots of quality)

$P_a = 0.9397$

The AOQ will be

(a) 0.93 % (b) 0.84 % (c) 0.75 % (d) 0.66 %

128. Ans: (a)

Sol: AOQ (%) = $\left(\frac{(P_d \times P_a) \times N - n}{N}\right) \times 100$

$$= \left(\frac{0.01 \times 0.9397 \times (10000 - 89)}{10000}\right) \times 100 = 0.931\ \%$$

End of Solution

129. An engine is to be designed to have a minimum reliability of 0.8 and minimum availability of 0.98 over a period of 2×10^3 hr. The MTTR is nearly

(a) 168 hr (b) 174 hr (c) 183 hr (d) 188 hr

129. Ans: (c)

Sol: Reliability (R) = $e^{-\lambda t}$

$$0.8 = e^{-\lambda \times 2000}$$

Taking log on both sides:

$ln\,(0.8) = -2000\ \lambda \times ln(e)$

$$\lambda = 1.1157 \times 10^{-4}\ /\ \text{hr}$$

$$\text{MTBF} = \frac{1}{\lambda} = 8962.84$$

$$\text{Availability} = \frac{\text{MTBF}}{\text{MTBF} + \text{MTTR}}$$

$$0.98 = \frac{8962.84}{8962.84 + \text{MTTR}}$$

MTTR = 182.915 hr $\approx$ 183 hr

End of Solution

130. Which one of the following relations with usual notations will hold good in a dynamic vibration absorber system under tuned conditions?

(a) $k_1k_2 = m_1m_2$ (b) $k_1m_2 = m_1k_2$

(c) $k_1m_1 = k_2m_2$ (d) $k_1 + k_2 = m_1 + m_2$

130. Ans: (b)

Sol: For turning of dynamic vibration absorber,

$$\sqrt{\frac{k_1}{m_1}} = \sqrt{\frac{k_2}{m_2}} \quad \text{i.e., } k_1m_2 = k_2m_1$$

131. In ultrasonic waves, the frequencies for non-destructive testing of materials are in the range of

(a) 0.5 MHz to 10 MHz (b) 10 MHz to 20 MHz

(c) 20 MHz to 30 MHz (d) 30 MHz to 40 MHz

131. Ans: (a)

Sol: Generally sound waves range is from 0.5 MHz to 15 MHz but in answer option (a) is close to above.

End of Solution

132. The Curie point for most ferrous magnetic materials is about

(a) 390°C (b) 540 °C (c) 760 °C (d) 880 °C

132. Ans: (c)

Sol: The ferrous magnetic materials depend on temperature and follow Curies-Wies law

$$\alpha = \frac{C}{T - T_{cw}}$$

At curie-Wies temperature, ferromagnetic materials convert into paramagnetic materials.

Ex: Curie temperature of ferrous (Fe) magnetic material is 768°C.

End of Solution

133. Which of the following is one of the basic units of memory controller in micro-controller?

(a) Microcode engine (b) Master program counter

(c) Program status word (d) Slave program counter

133. Ans: (a)

Sol: Microcode engine is one of the basic units of memory controller in micro-controller.

End of Solution

134. Which one of the following ways will be adopted to store the program counter contents?

(a) last-in-First-out (LIFO) (b) First-in-First-out (FIFO)

(c) Last-in-Last-out (LILO) (d) First-in-Last-out (FILO)

134. Ans: (a)

Sol: Sub routines are called from many different points in a program. It is necessary to store the program counter contents in last in first out (LIFO). Such register is referred as stack.

End of Solution

ESE / GATE / PSUs - 2020 ADMISSIONS OPEN

CENTER	COURSE	BATCH TYPE	DATE
HYDERABAD - DSNR	GATE + PSUS – 2020	Regular Batches	26th April, 11th, 25th May, 09th, 24th June, 8th July 2019
HYDERABAD - DSNR	ESE + GATE + PSUs - 2020	Regular Batches	21st March, 26th April, 11th, 25th May, 09th, 24th June, 8th July 2019
HYDERABAD - DSNR	GATE + PSUs - 2020	Short Term Batches	29th April, 6th, 11th, 18th May 26th May, 2nd June, 2019
HYDERABAD - DSNR	GATE + PSUs - 2020	Morning/Evening Batch	21st Jan 2019
HYDERABAD - DSNR	ESE – 2019 STAGE-II (MAINS)	Regular Batch	17th Feb 2019
HYDERABAD - Abids	GATE + PSUS – 2020	Regular Batches	26th April, 11th, 25th May, 09th, 24th June, 8th July 2019
HYDERABAD - Abids	GATE + PSUs - 2020	Short Term Batches	29th April, 6th, 11th, 18th May 26th May, 2nd June, 2019
HYDERABAD - Abids	ESE + GATE + PSUs - 2020	Morning Batch	21st Jan 2019
HYDERABAD - Abids	ESE – 2019 STAGE-II (MAINS)	Regular Batch	17th Feb 2019
HYDERABAD - Abids	GATE + PSUs - 2020	Weekend Batch	19th Jan 2019
HYDERABAD - Abids	ESE+GATE + PSUs - 2020	Spark Batches	11th May, 09th June 2019
HYDERABAD - Kukatpally	GATE + PSUs - 2020	Morning/Evening Batch	21st Jan 2019
HYDERABAD - Kukatpally	GATE + PSUS – 2020	Regular Batches	17th May, 1st, 16th June, 1st July 2019
HYDERABAD - Kukatpally	GATE + PSUs - 2020	Short Term Batches	29th April, 6th, 11th, 18th May 26th May, 2nd June, 2019
HYDERABAD - Kothapet	ESE + GATE + PSUS – 2020	Regular Batches	21st March, 26th April, 11th, 25th May, 09th, 24th June, 8th July 2019
HYDERABAD - Kothapet	ESE+GATE + PSUs - 2020	Spark Batches	11th May, 09th June 2019
DELHI	ESE+GATE+PSUs - 2020	Weekend Batches	13th Jan, 2nd Feb 2019
DELHI	ESE+GATE+PSUs - 2020	Regular Evening Batch	18th Feb 2019
DELHI	ESE+GATE+PSUs - 2020	Regular Day Batch	11th May 2019
DELHI	ESE+GATE+PSUs - 2020	Spark Batch	11th May 2019
DELHI	ESE+GATE+PSUs - 2021	Weekend Batch	13th Jan 2019
DELHI	GATE+PSUs - 2020	Short Term Batches	11th, 23rd May 2019
BHOPAL	ESE + GATE+PSUs - 2020 & 21	Evening Batch	09th Jan 2019
BHOPAL	ESE+GATE+PSUs - 2020	Regular Day Batch	01st Week of June 2019
PUNE	GATE+PSUs - 2020	Weekend Batch	19th Jan 2019
PUNE	ESE+GATE+PSUs - 2021	Weekend Batch	26th Jan 2019
BHUBANESWAR	GATE+PSUs - 2020 & 21	Weekend Batch	12th Jan 2019
BHUBANESWAR	GATE+PSUs - 2020	Regular Batch	02nd Week of May 2019

135. In ladder logic programming, an alternative in place of using same internal relay contact for every rung is to use

(a) battery-backed relay
(b) dummy relay
(c) one-shot operation
(d) master control relay

135. Ans: (d)

Sol: Master control relay is used in ladder logic for whole block of outputs which can be simultaneously turned on/off.

End of Solution

136. Consider the following statements:

1. The term 'attenuation' is used to describe the process of removing a certain band of frequencies from a signal and permitting others to be transmitted.
2. The Wheatstone bridge can be used to convert a voltage change to an electrical resistance change.

Which of the above statements is/are correct?

(a) 1 only
(b) 2 only
(c) Both 1 and 2
(d) Neither 1 nor 2

136. Ans: (d)

Sol: Statement 1 and Statement 2 are incorrect.

End of Solution

137. At time *t*, the excitation voltage to a resolver is 24 V. The shaft angle is 90°. The output signals from the resolver V_{S1} and V_{S2} will be

(a) 12 V and 0 V
(b) 24 V and 0 V
(c) 12 V and 12 V
(d) 24 V and 12 V

137. Ans: (b)

Sol: Initially $\theta = 0°$

$\rightarrow \quad V_{s1} = 24 \cos 0°$

$\rightarrow \quad V_{s2} = 24 \sin 0°$

after $\theta = 90°$

$V_{s1} = 24 \cos 90° = 24$ V

$V_{s2} = 24 \sin 90° = 0$ V

End of Solution

138. An actuator having a stem movement at full travel of 30 mm mounted with a control valve having an equal percentage plug and with minimum flow rate of 2 m^3/s and maximum flow rate of 24 m^3/s. When the stem movement is 10 mm, the flow rate will be

(a) 3.4 m^3/s (b) 3.8 m^3/s

(c) 4.2 m^3/s (d) 4.6 m^3/s

138. Ans: (d)

Sol: $$Q = Q_m R^{\left(\frac{x}{T}-1\right)}$$

Flow rate, $(Q) = ?$

Maximum flow rate, $(Q_m) = 24\ m^3/s$

Valve range ability, $(R) = \dfrac{\text{maximum flow}}{\text{minimum flow}} = \dfrac{24}{2} = 12$

Maximum valve travel, (T) = 30 mm, x = 10 mm

So, $Q = 24 \times (12)^{\left(\frac{10}{30}-1\right)} = 24 \times (12)^{\frac{-2}{3}} = 4.6\,m^3/s$

End of Solution

139. In a rack and pinion system, rack is an element moving in translational direction and pinion is a rotary gear. Which one of the following statements is correct ?

(a) Translational acceleration is directly proportional to the moment of inertia of pinion.

(b) Translational acceleration is inversely proportional to the moment of inertia of pinion.

(c) Angular acceleration is inversely proportional to the torque on pinion shaft.

(d) Translational velocity is directly proportional to the moment of inertia of pinion.

139. Ans: (b)

Sol: Translational acceleration, $a_t = r\alpha$

where, r = radius of pinion,

α = angular acceleration of pinion

$$\alpha = \frac{\text{Torque}}{I_{pinion}}$$

$$a_t = \frac{r \times \text{Torque}}{I_{pinion}}$$

$$a_t \propto \frac{1}{I_{pinion}}$$

140. For the control signal to change at a rate proportional to the error signal, the robotic controller must employ

(a) integral control

(b) proportional-plus-integral control

(c) proportional-plus-derivative control

(d) proportional-plus-integral-plus-derivative control

140. Ans: (b)

Sol: Integral controller:

Controller output (P) $\propto \int e\,dt$ (or)

$$P \propto \int e\,dt \quad \text{or} \quad \frac{dp}{dt} \propto e$$

- But it is combined with proportional (Q) controller so
- Composite proportional plus integral controls is used.

Control signal changes at a rate proportional to error signal in robotic controller.

End of Solution

141. What is the minimum number of degrees of freedom that a robot needs to have in order to locate its end effectors at an arbitrary point with an arbitrary orientation in space?

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

141. Ans: (d)

Sol: The minimum number of co-ordinates required to locate body in Elucidean space is six (6) = 3+3

$\therefore$ Arbitrary means random and un predictable so minimum 3 + 3 = 6 dof

End of Solution

142. Using a robot with 1 degree of freedom and having 1 sliding joint with a full range of 1 m, if the robot's control memory has a 12-bit storage capacity, the control resolution for the axis of motion will be

(a) 0.236 mm (b) 0.244 mm

(c) 0.252 mm (d) 0.260 mm

142. Ans: (b)

Sol: Control resolution $= \frac{1\,m}{2^{12}} = 0.244\,mm$

End of Solution

143. Assume that the joint mechanisms at serial link manipulators are frictionless. The joint torque τ required to bear an arbitrary end point force F is

(a) $J^{-1}F$ (b) JF (c) $J^{T}F$ (d) $J^{-1}F^{T}$

143. Ans: (c)

Sol: Joint torque $\tau = J^{T}F$

J^{T} = Transpose of Jacobian matrix

F = end-point force vector

End of Solution

144. Rotate the vector $v = 5i + 3j + 8k$ by an angle of 90° about the x-axis. The rotated vector (Hv) would be

(a) $\begin{bmatrix} 1 \\ 3 \\ -8 \\ 5 \end{bmatrix}$ (b) $\begin{bmatrix} -8 \\ 5 \\ 1 \\ 3 \end{bmatrix}$ (c) $\begin{bmatrix} 3 \\ -8 \\ 5 \\ 1 \end{bmatrix}$ (d) $\begin{bmatrix} 5 \\ -8 \\ 3 \\ 1 \end{bmatrix}$

144. Ans: (d)

Sol: $R(x, 90^\circ) = \begin{bmatrix} 1 & 0 & 0 \\ 0 & \cos 90^\circ & -\sin 90^\circ \\ 0 & \sin 90^\circ & \cos 90^\circ \end{bmatrix}$

$$\Rightarrow \begin{bmatrix} 1 & 0 & 0 \\ 0 & 0 & -1 \\ 0 & 1 & 0 \end{bmatrix}\begin{bmatrix} 5 \\ 3 \\ 8 \end{bmatrix} = \begin{bmatrix} 5 \\ -8 \\ 3 \end{bmatrix}$$

Rotated vector $= 5i - 8j + 3k \Rightarrow \begin{bmatrix} 5 \\ -8 \\ 3 \\ 1 \end{bmatrix}$

End of Solution

Directions:

*Each of the **Six (6)** items consists of two statements, one labelled as the 'Statement (I)' and the other as 'Statement (II)'. You are to examine these two statements carefully and select the answers to these items using the codes given below:*

Codes:

(a) Both Statement (I) and Statement (II) are individually true and Statement (II) is the correct explanation of Statement (I)

*(b) Both Statement (I) and Statement (II) are individually true but Statement (II) is **not** the correct explanation of Statement (I)*

(c) Statement (I) is true but Statement (II) is false

(d) Statement (I) is false but Statement (II) is true

145. **Statement (I):** The function of arithmetic logic unit (ALU) in microprocessor is to perform data manipulation.

Statement (II): The status register is where data for an input to the arithmetic and logic unit is temporarily stored.

145. Ans: (c)

Sol: Statement (I) is true

Statement (II) is false,

Status register (flag register) consists of flag bits indicates status of ALU after data process/manipulation.

End of Solution

146. **Statement (I):** To use a sensor, we generally need to add signal conditioning circuitry, such as circuits which amplify and convert from analog to digital, to get the sensor signal in the right form, take account of any non-linearities, and calibrate it.

Statement (II): A smart sensor is integrated with the required buffering and conditioning circuitry in a single element and provides functions beyond that of just a sensor.

146. Ans: (b)

End of Solution

147. **Statement (I):** The count-up overflow (OV) bit is 1 when the up-counter increments above the maximum positive value.

Statement (II): The count-down underflow (UN) bit is 1 when the counter decrements below the minimum negative value.

147. Ans: (b)

End of Solution

148. **Statement (I):** The multiplexer is essentially an electronic switching device which enables each of the inputs to be sampled in turn.

Statement (II): A multiplexer is a circuit that is able to have inputs of data from a number of sources and then, by selecting an input channel, gives an output from just one of them.

148. Ans: (a)

End of Solution

149. **Statement (I):** The term 'encoder' is used for a device that provides an analog output as a result of angular or linear displacement.

Statement (II): An increment encoder detects changes in angular or linear displacement from some datum position where as an absolute encoder gives the actual angular or linear position.

149. Ans: (b)

Sol: Statements I and II are correct.

Statement (I) Encoder sensor is electro mechanical device, which may be contact type (or) non-contact type and converts angular (or) linear displacement into Analog (or) digital outputs, as per signal conditions circuit. Statement (II) is also correct.

End of Solution

150. **Statement (I):** Process control valves are used to control the rate of fluid flow and are used where, perhaps, the rate of flow of a liquid into a tank has to be controlled.

Statement (II): A common form of pneumatic actuator used with process control valves is the diaphragm actuator.

150. Ans: (b)

End of Solution