Mechanical Engineering

Q. No. 1 to 25 Carry One Mark Each

1. A motor driving a solid circular steel shaft transmits 40kW of power at 500 rpm. If the diameter of the shaft is 40 mm, the maximum shear stress in the shaft is ________MPa.

Key: 60 to 61

Exp: P=40kW N=500rpm

D= 40mm $T = \frac{16T}{\pi d^3}$

$$T = \frac{P \times 60,000}{2\pi N} = \frac{40 \times 60,000}{2\pi \times 500} = 763.94 N - m$$

$$\tau = \frac{16 \times 763.94 \times 10^3}{\pi \times (40)^3} = 60.79 MPa$$

2. Consider the following partial differential equation for u(x,y) with the constant c > 1 :

$$\frac{\partial u}{\partial y} + c\frac{\partial u}{\partial x} = 0$$

Solution of this equation is

(A) $u(x,y) = f(x+cy)$ (B) $u(x,y) = f(x-cy)$

(C) $u(x,y) = f(cx+y)$ (D) $u(x,y) = f(cx-y)$

Key: (B)

Exp: Given $\frac{\partial u}{\partial y} + c\frac{\partial u}{\partial x} = 0$

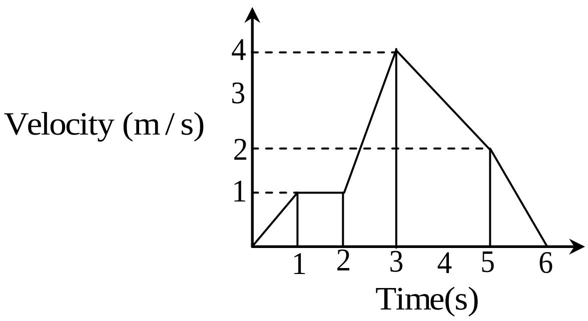
$$\frac{\partial u}{\partial x} = f'(x-cy)$$

$$\frac{\partial u}{\partial x} = -c f'(x-cy)$$

$$\frac{\partial u}{\partial x} + \frac{\partial u}{\partial y} = 0$$

$$u(x,y) = f(x-cy)$$

3. The following figure shows the velocity- time plot for a particle traveling along a straight line. The distance covered by the particle from t = 0 to t= 5 s is __________m.



Key: **10 to 10**

Exp: Area under V- T wave

$$S = a_1 + a_2 + a_3 + a_4 + a_5$$

$$= \left[\frac{1}{2}(1)(1)\right] + [1\times 1] + \left[\left(\frac{1+4}{2}\right)\times 1\right] + \left[\left(\frac{4+2}{2}\right)\times 2\right]$$

$$= 0.5 + 1 + 2.5 + 6 = 10m$$

4. The damping ratio for a viscously damped spring mass system, governed by the relationship $m\frac{d^2x}{dt^2} + C\frac{dx}{dt} + kx = F(t)$, is given by

(A) $\sqrt{\frac{c}{mk}}$ (B) $\frac{c}{2\sqrt{km}}$ (C) $\frac{c}{\sqrt{km}}$ (D) $\sqrt{\frac{c}{2mk}}$

Key: **(B)**

Exp: $m\frac{dx^2}{dt^2} + c\frac{dx}{dt} + k_x = F(t);$ $\xi = \frac{c}{c_c} = \frac{c}{2\sqrt{km}}$

5. The differential equation $\frac{d^2y}{dx^2} + 16y = 0$ for $y(x)$ with the two boundary conditions $\left.\frac{dy}{dx}\right|_{x=0} = 1$ and $\left.\frac{dy}{dx}\right|_{x=\frac{\pi}{2}} = -1$ has

(A) no solution (B) exactly two solutions

(C) exactly one solution (D) infinitely many solutions

Key: **(A)**

Exp: $\frac{d^2y}{dx^2} + 16y = 0$ $\left.\frac{dy}{dx}\right|_{x=0} = 1$ $\left.\frac{dy}{dx}\right|_{x=\frac{\pi}{2}} = -1$

$\Rightarrow m^2 + 16 = 0$

$m = 0 \pm 4i$

$y_c = c_1\cos 4x + c_2 \sin 4x$ and $y_p = 0$

$\therefore y = c_1 \cos 4x + c_2 \sin 4x$

$y'(x) = -4c_1 \sin 4x + 4c_2 \cos 4x$

$y'(0) = 1 \Rightarrow 0 + 4c_2 = 1 \Rightarrow c_2 = \frac{1}{4}$

$y'\left(\frac{\pi}{2}\right) = -1 \Rightarrow 0 + 4c_2 = -1 \Rightarrow c_2 = \frac{-1}{4}$

$c_2 = \frac{1}{4}$ and $\frac{-1}{4}$ both not possible

Hence there is no solution

6. Metric thread of 0.8 mm pitch is to be cut on a lathe. Pitch of the lead screw is 1.5 mm. If the spindle rotates at 1500 rpm, the speed of rotation of the lead screw (rpm) will be __________

Key: **800 to 800**

Exp: Speed of rotation of lead screw $=\dfrac{1500\times 0.8}{1.5}=800\text{rpm}$

7. The molar specific heat at constant volume of an ideal gas is equal to 2.5 times the universal gas constant (8.314 J/mol.K). When the temperature increases by 100K, the change in molar specific enthalpy is _______________ J/mol.

Key: **2908 to 2911**

Exp: $C_v=2.5R_v$ where $\left(R_v=8.314\,\text{J/mol.K}\right)$

$\Delta T=100\text{K}$

$\Delta H=?$

$\Delta H=C_p\Delta T$

$\because C_p-C_v=R_v$

$[C_p=3.5R_v]$

So, $\Delta H=3.5\times 8.314\times 100$

$[\Delta H=2909.9\,\text{J/mol}]$

8. A particle of unit mass is moving on a plane. Its trajectory, in polar coordinates, is given by $r(t)=t^2,\ \theta(t)=t,$ where t is time. The kinetic energy of the particle at time t = 2 is

(A) 4 (B) 12 (C) 16 (D) 24

Key: **(C)**

Exp: $r=t^2;\theta=t$

$K.E=\dfrac{1}{2}mv^2=?$ at $t=2$ sec

$\Rightarrow m=1\text{kg}$

$V=r\omega(\hat{t})+\dfrac{dr}{dt}\hat{r}=t^2\times 1(\hat{t})+2t\hat{r}$

$V=t^2(\hat{t})+2t(\hat{r})$

at $t=2s$

$V=4(\hat{t})+4(\hat{r})$

$|V|=\sqrt{16+16}=\sqrt{32}$

$K.E.=\dfrac{1}{2}mv^2=\dfrac{1}{2}\times 1\times 32=16$

9. The Poisson's ratio for a perfectly incompressible linear elastic material is

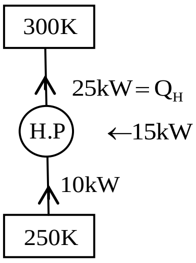
(A) 1 (B) 0.5 (C) 0 (D) infinity

Key: **(B)**

10. A heat pump absorbs 10 kW of heat from outside environment at 250 K while absorbing 15 kW of work. It delivers the heat to a room that must be kept warm at 300K. The Coefficient of Performance (COP) of the heat pump is ___________.

Key: **1.66 to 1.70**

Exp:



$$COP = \frac{Q_H}{W_{i/p}} = \frac{25}{15} = 1.66$$

11. Which one of the following is NOT a rotating machine?

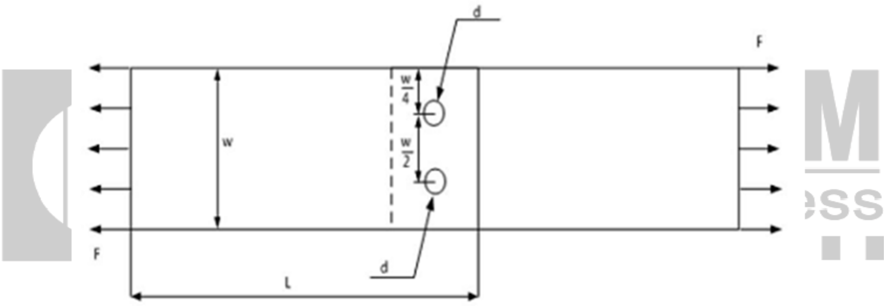
(A) Centrifugal pump (B) Gear pump

(C) Jet pump (D) Vane pump

Key: **(C)**

Exp: In the given options all the pumps have rotating machine elements except Jet pump.

12. Consider the schematic of a riveted lap joint subjected to tensile load F, as shown below. Let *d* be the diameter of the rivets, and S_f be the maximum permissible tensile stress in the plates. What should be the minimum value for the thickness of the plates to guard against tensile failure of the plates? Assume the plates to be identical.



(A) $\frac{F}{S_f(W-2d)}$ (B) $\frac{F}{S_f W}$ (C) $\frac{F}{S_f(W-d)}$ (D) $\frac{2F}{S_f W}$

Key: **(A)**

Exp: $S_f = \frac{F}{A} \Rightarrow S_f = \frac{F}{t(W-2d)}$; $\quad t = \frac{F}{S_f(w-2d)}$

13. Water (density =1000 kg/m^3) at ambient temperature flows through a horizontal pipe of uniform cross section at the rate of 1 kg/s. If the pressure drop across the pipe is 100 kPa, the minimum power required to pump the water across the pipe, in watts, is ________

Key: **100 to 100**

Exp: given,

$\rho_w = 1000\,kg/m^3$

$\dot{m} = 1kg/s$

$\Delta P = 10kPa$

$$\text{So, minimum power require} = \dot{m}\,g h_f$$
$$= \dot{m}\,g\left(\frac{\Delta P}{\rho g}\right)$$
$$= \frac{1\times100\times1000}{1000} = 100\,\text{Watts}$$

14. For steady flow of a viscous incompressible fluid through a circular pipe of constant diameter, the average velocity in the fully developed region is constant. Which one of the following statements about the average velocity in the developing region is TRUE?

(A) It increases until the flow is fully developed.

(B) It is constant and is equal to the average velocity in the fully developed region.

(C) It decreases until the flow is fully developed.

(D) It is constant but always lower than the average velocity in the fully developed region.

Key: (B)

Exp: The average velocity in pipe flow always be same either for developing flow or fully developed flow.

15. Cylindrical pins of diameter $15^{\pm 0.020}$ mm are being produced on a machine. Statistical quality control tests show a mean of 14.995 mm and standard deviation of 0.004mm. The process capability index C_p is

(A) 0.833 (B) 1.667 (C) 3.333 (D) 3.750

Key: (B)

Exp: $C_p = \frac{USL - LSL}{6\sigma} = \frac{15.02 - 14.98}{6 \times 0.004} = 1.666$

16. The product of Eigen values of the matrix P is $P = \begin{bmatrix} 2 & 0 & 1 \\ 4 & -3 & 3 \\ 0 & 2 & -1 \end{bmatrix}$

(A) -6 (B) 2 (C) 6 (D) -2

Key: (B)

Exp: $P = \begin{bmatrix} 2 & 0 & 1 \\ 4 & -3 & 3 \\ 0 & 2 & -1 \end{bmatrix}$

We know that, product of eigen values of P = determinant of P

$= 2(3-6) - 0 + 1(8) = -6 + 8 = 2$

17. Match the processes with their characteristics.

Process	Characteristics
P : Electrical Discharge machining	1. No residual stress
Q : Ultrasonic machining	2. Machining of electrically conductive materials
R : Chemical machining	3. Machining of glass
S : Ion Beam Machining	4. Nano-machining

(A) P – 2, Q – 3, R – 1, S – 4 (B) P – 3, Q – 2, R – 1, S – 4

(C) P – 3, Q – 2, R – 4, S – 1 (D) P – 2, Q – 4, R – 3, S – 1

Key: (A)

18. The Value of $\lim_{x\to 0}\dfrac{x^3-\sin(x)}{x}$ is

(A) 0 (B) 3 (C) 1 (D) -1

Key: (D)

Exp: $\underset{x\to 0}{\ell t}\dfrac{x^3-\sin x}{x}=\left(\underset{x\to 0}{\ell t}\,x^2\right)-\left(\underset{x\to 0}{\ell t}\dfrac{\sin x}{x}\right)=0-1=-1$

19. In an arc welding process, welding speed is doubled. Assuming all other process parameters to be constant, the cross sectional area of the weld bead will

(A) Increase by 25% (B) Increase by 50% (C) Reduce by 25% (D) Reduce by 50%

Key: (D)

Exp: $\therefore V.I=H_m A.V$

$A\propto\dfrac{1}{V}$

$\dfrac{A_2}{A_1}=\dfrac{V_1}{V_2}=\dfrac{V}{2V}$

$A_2=\dfrac{A_1}{2}$

By doubling welding speed, Area reduces by 50%

20. A six-face fair dice is rolled a large number of times. The mean value of the outcomes is ______.

Key: 3.5 to 3.5

Exp: The Probabilities corresponding to the outcomes are given below:

Face	1	2	3	4	5	6
Probability	1/6	1/6	1/6	1/6	1/6	1/6

$\text{mean}=E(x)=\sum x.P(x)$

$=1\left(\frac{1}{6}\right)+2\left(\frac{1}{6}\right)+3\left(\frac{1}{6}\right)+4\left(\frac{1}{6}\right)+5\left(\frac{1}{6}\right)+6\left(\frac{1}{6}\right)$

$=\dfrac{1}{6}[1+2+3+4+5+6]=\dfrac{21}{6}=3.5$

21. Consider the two dimensional velocity field given by $\vec{V}=(5+a_1x+b_1y)\hat{i}+(4+a_2x+b_2y)\hat{j}$, wher a_1, b_1, a_2 and b_2 are constants. Which one of the following conditions needs to be satisfied for the flow to be incompressible?

(A) $a_1+b_1=0$ (B) $a_1+b_2=0$ (C) $a_2+b_2=0$ (D) $a_2+b_1=0$

Key: (B)

Exp: Given $\vec{V}=(5+a_1x+b_1y)\hat{i}+(4+a_2x+b_2y)\hat{j}$

For Incompressible $\Delta\vec{V}=0$; i.e., $\dfrac{\partial u}{\partial x}=\dfrac{\partial V}{\partial y}=0$

$a_1+b_2=0$

22. Consider a beam with circular cross-section of diameter *d*. The ratio of the second moment of area about the neutral axis to the section modulus of the area is.

(A) $\frac{d}{2}$ (B) $\frac{\pi d}{2}$ (C) d (D) πd

Key: (A)

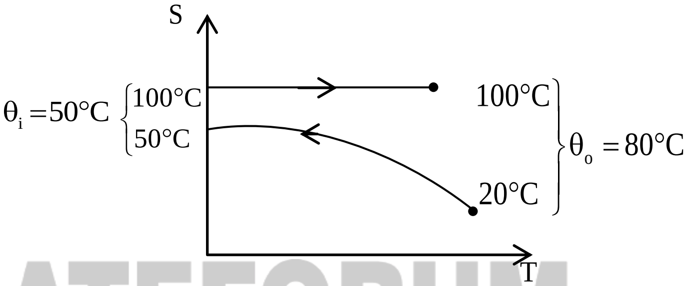
Exp: $Z = \frac{I}{y} \Rightarrow y = \frac{I}{Z} = \frac{\frac{\pi}{64}d^4}{\frac{\pi}{32}d^3} = \frac{d}{2}$

23. Saturated steam at 100°C condenses on the outside of a tube. Cold fluid enters the tube at 20°C and exists at 50°C. The value of the Log Mean Temperature Difference (LMTD) is ________°C.

Key: 63.5 to 64

Exp: $\text{LMTD} = \frac{\theta_o - \theta_i}{\ell n(\theta_o/\theta_i)} = \frac{80-50}{\ell n(80/50)}$

$\text{LMTD} = 63.82°C$



24. In a metal forming operation when the material has just started yielding, the principal stresses are $\sigma_1 = +180$ MPa, $\sigma_2 = -100$ MPa, $\sigma_3 = 0$. Following Von Mises criterion, the yield stress is ________ MPa.

Key: 245 to 246

Exp: As per Von-Mises criteria

$$(\sigma_1 - \sigma_2)^2 + (\sigma_1 - \sigma_3)^2 + (\sigma_5 - \sigma_1)^2 = 2\sigma_m^2$$

$$(180+100)^2 + (-100-0)^2 + (0-180)^2 = 2\sigma_m^2$$

$$\sigma_m = 245.76\text{MPa}$$

25. In the engineering stress-strain curve for mild steel, the Ultimate Tensile Strength (UTS) refers to

(A) Yield stress (B) Proportional limit
(C) Maximum stress (D) Fracture stress.

Key: (C)

Q. No. 26 to 55 Carry Two Marks Each

26. A parametric curve defined by $x = \cos\left(\frac{\pi u}{2}\right), y = \sin\left(\frac{\pi u}{2}\right)$ in the range $0 \le u \le 1$ is rotated about the X – axis by 360 degrees. Area of the surface generated is.

(A) $\frac{\pi}{2}$ (B) π (C) 2π (D) 4π

Key: (C)

Exp: Given $x=\cos\left(\frac{\pi u}{2}\right), y=\sin\left(\frac{\pi u}{2}\right)\quad 0\le \mu\le 1$

$$\frac{dx}{d\mu}=\frac{-\pi}{2}\sin\left(\frac{\pi u}{2}\right)$$

$$\frac{dy}{dx}=\frac{\pi}{2}\cos\frac{\pi u}{2}$$

We know that surface area when the curve revolved about X- axis of a parametric curve is

$$=2\pi\int_0^1 y\sqrt{\left(\frac{dx}{du}\right)^2+\left(\frac{dy}{du}\right)^2}du=2\pi\int_0^1\sin\left(\frac{\pi u}{2}\right)\sqrt{\left(\frac{-\pi}{2}\sin\left(\frac{\pi u}{2}\right)\right)^2+\left(\frac{\pi}{2}\cos\left(\frac{\pi u}{2}\right)\right)^2}du$$

$$=2\pi\int_0^1\sin\frac{\pi u}{2}\sqrt{\frac{\pi^2}{4}}du=2\pi\times\frac{\pi}{2}\int_0^1\sin\frac{\pi u}{2}dx=\pi^2\left(\frac{-1\cos\frac{\pi u}{2}}{\pi/2}\right)_0^1=-\pi^2\times\frac{2}{\pi}\left[\cos\frac{\pi}{2}-\cos 0\right]$$

$$=-2\pi[\cos 0-1]=2\pi$$

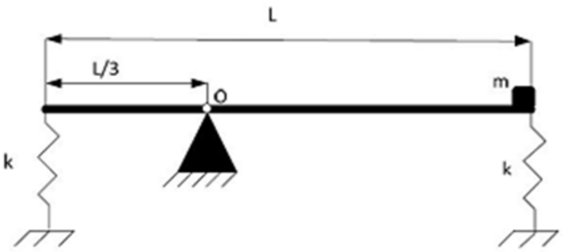
27. Assume that the surface roughness profile is triangular as shown schematically in the figure. If the peak to valley height is $20\,\mu m$, The central line average surface roughness R_a (in μm) is

(A) 5 (B) 6.67 (B) 10 (D) 20

Key: **(A)**

Exp: $R_a=\frac{R_{max}}{4}=\frac{20}{4}=5\mu m$

28. A thin uniform rigid bar of length L and mass M is hinged at point O, located at a distance of $\frac{L}{3}$ from one of its ends. The bar is further supported using springs, each of stiffness k, located at the two ends. A particle of mass $m=\frac{M}{4}$ is fixed at one end of the bar, as shown in the figure. For small rotations of the bar about O, the natural frequency of the systems is.



(A) $\sqrt{\frac{5k}{M}}$ (B) $\sqrt{\frac{5k}{2M}}$ (C) $\sqrt{\frac{3k}{2M}}$ (D) $\sqrt{\frac{3k}{M}}$

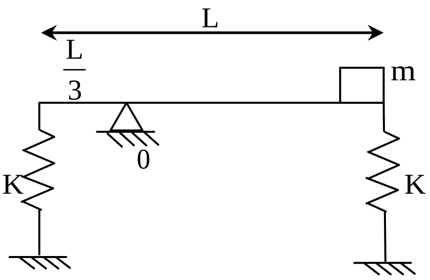
Key: **(B)**

Exp: Max moment of inertia of Rod.

$$I_0 = I_c + mr^2$$

$$I_0 = \frac{ML^2}{12} + M\left(\frac{2L}{3} - \frac{L}{2}\right)^2$$

$$I_0 = \frac{ML^2}{12} + \frac{ML^2}{36} = \frac{ML^2}{9}$$



Mass moment of inertia of particular mass

$$I_{particular} = \frac{M}{4} \times \left(\frac{2L}{3}\right)^2 = \frac{ML^2}{9}$$

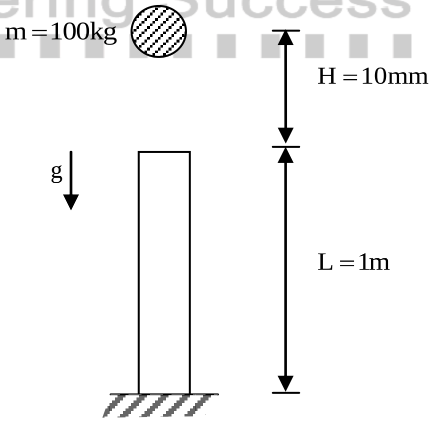
$$I_{Total} = \frac{ML^2}{9} + \frac{ML^2}{9} = \frac{2(ML^2)}{9}$$

$$\sum M_0 = 0$$

$$K\left(\frac{L}{3}\theta\right)\left(\frac{L}{3}\right) + K\left(\frac{2L}{3}\theta\right)\left(\frac{2L}{3}\right) + I\ddot{\theta} = 0$$

$$\left(\frac{2ML^2}{9}\right)\ddot{\theta} + K\left(\frac{5L^2}{9}\right)\theta = 0 \Rightarrow \omega_n = \sqrt{\frac{\frac{5L^2}{9}.k}{\frac{2ML^2}{9}}} = \sqrt{\frac{5k}{2M}}$$

29. A point mass of 100 kg is dropped onto a massless elastic bar (cross-sectional area = 100 mm^2, length = 1m, Young's moduls = 100 GPa) from a height H of 10mm as shown (Figure is not to scale). If g = 10m/s^2, the maximum compression of the elastic bar is ________ mm.



Key: 1.50 to 1.52

Exp: Given that

$$m = 100kg,\ g = 10\,m/sec^2,\ E = 100GPa$$

$$H = 10mm,\ L = 1m = 100mm,$$

$$A = 100mm^2$$

From the given figure, we can say that this is case of Impact loading,

We know that, stress due to Impact load is

$$\sigma_{I.L} = \frac{P}{A} + \sqrt{\left(\frac{P}{A}\right)^2 + \left(\frac{2PhE}{AL}\right)}$$

$$P = mg = 100 \times 10 = 1000N$$

$$\sigma_{I.L} = \frac{1000}{100} + \sqrt{\left(\frac{1000}{100}\right)^2 + \left(\frac{2 \times 1000 \times 10 \times 1 \times 10^5}{100 \times 1000}\right)} = 151.7745\ N/mm^2$$

$$\text{Compression}\,(\delta\ell) = \frac{\sigma_{I.L} \times L}{E} = \frac{151.7745 \times 1000}{1 \times 10^5} = 1.5177\ mm$$

30. One kg of an ideal gas (gas constant, R = 400 J/kg.K; specific heat at constant volume, $c_v = 1000 J/kg.K$) at 1 bar, and 300 K is contained in a sealed rigid cylinder. During an adiabatic process, 100kJ of work is done on the system by a stirrer. The increase in entropy of the system is __________ J/K.

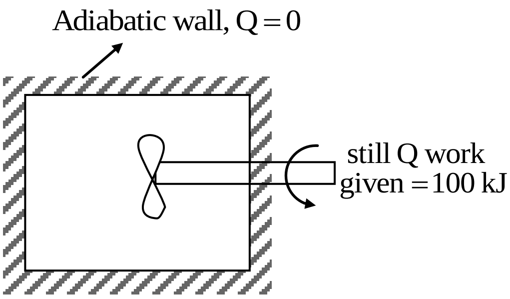
Key: **286 to 288**

Exp: Given that $m = 1kg,\ R = 400\ kJ/kgK,\ C_V = 1000\ J/kgK$

$P_1 = 1\ bar,\ T_1 = 300K$

Since the gas is contained in a sealed rigid cylinder, and given that adiabatic process is done to the system, means no heat is transferred from/to the system, Q = 0

And we know from first law of thermo dynamics,



$$Q = du + W$$

$$0 = mC_V (T_2 - T_1) - 100\times10^3 \left(\because du = mC_V (T_2 - T_1)\right)$$

$$mC_V (T_2 - T_1) = 100\times10^3$$

$$1\times1000 (T_2 - 300) = 100\times10^3$$

$$T_2 = \frac{100\times10^3}{1000} + 300 = 400K$$

We know that the first law of thermodynamics can be written as

$$Tds = mC_V dT + pdV$$

$$ds = mC_V \frac{dT}{T} + \frac{P}{T} dv \qquad \left(\because PV = mRT \Rightarrow P = \frac{mRT}{V}\right)$$

$$ds = mC_V \frac{dT}{T} + \frac{mRT}{rT} dV = mC_V \frac{dT}{T} + mR \frac{dV}{V}$$

Entropy increase $(S_2 - S_1) = mC_V \ell n\left(\frac{T_2}{T_1}\right) + mR\ell_n \left(\frac{V_2}{V_1}\right)$

Since the above process is a constant volume process that is $V_2 = V_1$

$$\Rightarrow (S_2 - S_1) = (1)\times(1000)\times \ell n\left(\frac{400}{300}\right) = 287.6821\ J/K$$

31. For an inline slider-crank mechanism, the lengths of the crank and connecting rod are 3m and 4m, respectively. At the instant when the connecting rod is perpendicular to the crank, if the velocity of the slider is 1m/s, the magnitude of angular velocity (upto 3 decimal points accuracy) of the crank is __________ radian/s.

Key: **0.26 to 0.27**

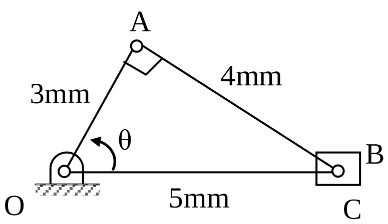
Exp: Given that velocity of slider

$V_B = 1m/sec$

Length of crank (OA) = 3m

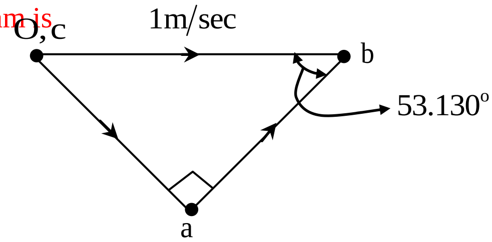
Length of connecting rod (AB) = 4m

From the configuration diagram



$$\sin\theta = \frac{A}{5} \Rightarrow \theta = 53.130^\circ$$

The velocity diagram for the above configuration diagram is



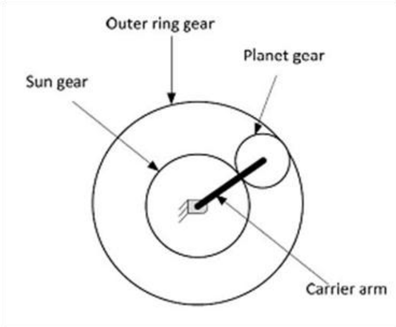
$\therefore$ From velocity diagram $\sin 53.13^{o} = \dfrac{Oa}{Ob}$

$\Rightarrow Oa = (1)\sin 53.130^{o} = 0.8$

$\Rightarrow V_A = Oa = OA \times \omega_{OA} = 0.8$

Angular velocity of crank $(\omega_{OA}) = \dfrac{0.8}{3} = 0.267$ rad/sec

32. In an epicyclic gear train, shown in the figure, the outer ring gear is fixed, while the sun gear rotates counterclockwise at 100rpm. Let the number of teeth on the sun, planet and outer gears to be 50, 25, and 100, respectively. The ratio of magnitudes of angular velocity of the planet gear to the angular velocity of the carrier arm is __________.



Key: 3 to 3

Exp: $T_S = 50$

$T_P = 25$

$T_R = 100$

S.No	Condition of motion	Arm Gear A	Gear S	Gear P	Gear R
1	Arm is fixed gear S with +1 revolution	0	+1	$-\dfrac{T_s}{T_P}$	$-\dfrac{T_s}{T_R}$
2	Arm is fixed Gear S with +x revolution	0	+x	$-x\dfrac{T_s}{T_P}$	$-x\dfrac{T_s}{T_R}$
3	Arm with + y revolution	y	y	y	y
4	Total	y	x+y	$y - x\dfrac{T_s}{T_P}$	$y - \dfrac{T_s}{T_R}x$

$N_S = x + y = 100 \qquad ...(1)$

$N_R = y - \dfrac{50}{100}x = 0$

$y = 0.5x \qquad ...(2)$

$x + 0.5x = 100$

$x = \dfrac{100}{1.5} = 66.66\text{rpm}$

$y = 33.34\,\text{rpm}$

$N_P = 33.34 - \left(66.66 \times \dfrac{50}{25}\right) = -99.99\text{rpm}$

$\dfrac{N_P}{N_{arm}} = \dfrac{-99.99}{33.32} = 3(\text{approx})$

33. Moist air is treated as an ideal gas mixture of water vapor and dry air (molecular weight of air = 28.84 and molecular weight of water = 18). At a location, the total pressure is 100 kPa, the temperature is 30°C and the relative humidity is 55%. Given that the saturation pressure of water at 30°C is 4246 Pa, the mass of water vapor per kg of dry air is _____________ grams.

Key: 14.7 to 15.1

Exp: $M_a = 28.84$

$M_w = 18$

$P = 100\text{kPa},\ T = 30°C,\ RH = 55\%,$

$P_s = 4246\text{Pa}$

$$\phi = \frac{P_v}{P_s} \Rightarrow 0.55 = \frac{P_v}{4246} \Rightarrow P_v = 2335.3\text{Pa}$$

$$\omega = 0.622\left(\frac{P_v}{P - P_v}\right) = 0.622 \times \left(\frac{2335.3}{100000 - 2335.3}\right)$$

$\omega = 0.01487\ \text{kg of vapour/kg of D.A}$

$\omega = 14.87\ \text{gm of vapour/kg of D.A}$

34. Following data refers to the jobs (P, Q, R, S) which have arrived at a machine for scheduling. The shortest possible average flow time is ___________ days.

Job	**Processing Time (days)**
P	15
Q	9
R	22
S	12

Key: 31 (not matching with IIT key)

Exp: For shortest avg. flow time SPT rule is used

Job Sequence	Processing Time	In	Out	Flow Time
Q	9	0	9	9
S	12	9	21	21
P	15	21	36	36
R	22	36	58	58

$$\text{Min Avg. Flow time } = \frac{9 + 21 + 36 + 58}{4} = 31\ \text{days}$$

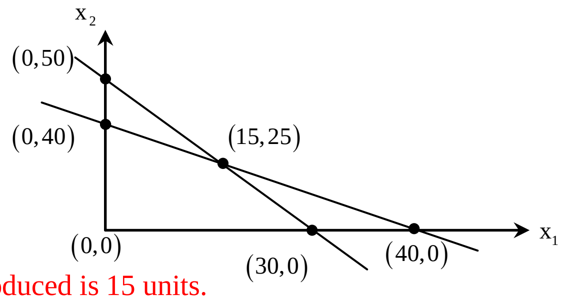
35. Two models, P and Q, of a product earn profits of Rs. 100 and Rs. 80 per piece, respectively. Production times for P and Q are 5 hours and 3 hours, respectively, while the total production time available is 150 hours. For a total batch size of 40, to maximize profit, the number of units of P to be produced is _____________.

Key: 15 to 15

Exp: Let $x_1 = \text{No. of units of P}$

$x_2 = \text{No. of units of Q}$

$$\text{max.}\quad z = 100x_1 + 80x_2$$
$$5x_1 + 3x_2 \le 150$$
$$x_1 + x_2 = 40$$



$$Z_{(0,40)} = \text{Rs.}3200$$
$$Z_{(15,225)} = \text{Rs.}3500 = \text{max. profit}$$

So, for maximum profit, No. of units of P produced is 15 units.

36. Circular arc on a part profile is being machined on a vertical CNC milling machine. CNC part program using metric units with absolute dimensions is listed below:

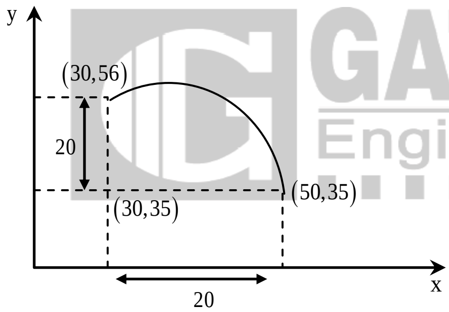
```
--------------------------------
N60  G01  X 30  Y  55  Z – 5 F 50
N70  G02  X 50  Y  35  R 20
N80  G01  Z 5
--------------------------------
```

The coordinates of the centre of the circular arc are :

(A) (30, 55) (B) (50, 55) (C) (50, 35) (D) (30, 35)

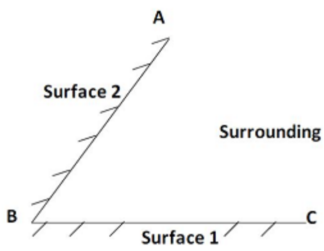
Key: (D)

Exp:



Centre of circular arc is (30, 35)

37. Two black surfaces, AB and BC, of lengths 5m and 6m, respectively, are oriented as shown. Both surfaces extend infinitely into the third dimension. Given that view factor F_{12}=0.5, T_1=800K, T_2=600K, $T_{surrounding}$=300K and Stefan Boltzmann constant, $\sigma = 5.67\times10^{-8}\,W/(m^2K^4)$, the heat transfer rate from Surface 2 to the surrounding environment is ____________ kW.



Key: 13.7 to 13.9

Exp: Given that two black surfaces ‘AB’ and ‘BC’

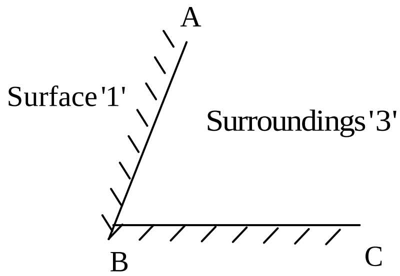
Length of AB = 5m, BC = 6 m

And temperature of

Surface ‘1’ $(T_{BC} = T_1) = 800^\circ K$

Temperature of surface ‘2’ $(T_{AB} = T_2 = 600^\circ K)$

Temperature of surroundings $(T_3) = 300^\circ K$



$\sigma = 5.67\times10^{-8}\,W/m^2K^4$

$F_{12} = 0.5$

W.K.T. $F_{11} = F_{22} = 0$, since they are flat surfaces

$F_{21} + F_{22} + F_{23} = 1$

$A_1F_{12} = A_2F_{21}$

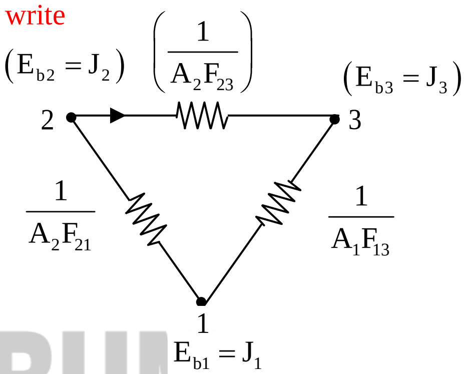
$\Rightarrow (6)(0.5) = (5)(F_{21})$ (Assume unit width for surfaces)

$\Rightarrow F_{21} = \frac{3}{5} = 0.6$

$0.6 + 0 + F_{23} = 1 \Rightarrow F_{23} = 1 - 0.6 = 0.4$

Using resistance concept we can draw as follows

Since surfaces are black and area of surrounding is large we can write



$E_{b1} = J_1, E_{b2} = J_2, E_{b3} = J_3$

$$Q_{23} = \frac{E_{b2} - E_{b3}}{\left(\frac{1}{A_2F_{23}}\right)} = \frac{\sigma\left(T_2^4 - T_3^4\right)}{\frac{1}{A_2F_{23}}}$$

$$= 5.67\times10^{-8}\times\left(600^4 - 300^4\right)\times5\times0.4$$

$$= 13.778\,kW/metre$$

38. Consider the matrix $P = \begin{bmatrix} \frac{1}{\sqrt{2}} & 0 & \frac{1}{\sqrt{2}} \\ 0 & 1 & 0 \\ \frac{-1}{\sqrt{2}} & 0 & \frac{1}{\sqrt{2}} \end{bmatrix}$.

Which one of the following statements about P is INCORRECT?

(A) Determinant of P is equal to 1.

(B) P is orthogonal.

(C) Inverse of P is equal to its transpose.

(D) All Eigen values of P are real numbers

Key: (D)

Exp: $P = \begin{bmatrix} \frac{1}{\sqrt{2}} & 0 & \frac{1}{\sqrt{2}} \\ 0 & 1 & 0 \\ -\frac{1}{\sqrt{2}} & 0 & \frac{1}{\sqrt{2}} \end{bmatrix}$

$$|P| = \frac{1}{\sqrt{2}}\left(\frac{1}{\sqrt{2}} - 0\right) - 0 + \frac{1}{\sqrt{2}}\left(\frac{1}{\sqrt{2}}\right) = \frac{1}{2} + \frac{1}{2} = 1$$

$$P.P^T = \begin{bmatrix} \frac{1}{\sqrt{2}} & 0 & \frac{1}{\sqrt{2}} \\ 0 & 1 & 0 \\ -\frac{1}{\sqrt{2}} & 0 & \frac{1}{\sqrt{2}} \end{bmatrix}\begin{bmatrix} \frac{1}{\sqrt{2}} & 0 & -\frac{1}{\sqrt{2}} \\ 0 & 1 & 0 \\ \frac{1}{\sqrt{2}} & 0 & \frac{1}{\sqrt{2}} \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

$\therefore$ P is an orthogonal matrix

(A) Is correct $\Rightarrow$ Inverse of P is its transpose only

$\therefore$ (B) and (C) both are correct

$\therefore$ (D) is incorrect

39. The Pressure ratio across a gas turbine (for air, specific heat at constant pressure, $c_p = 1040 J/kg.K$ and ratio of specific heats, $\gamma = 1.4$) is 10. If the inlet temperature to the turbine is 1200K and the isentropic efficiency is 0.9, the gas temperature at turbine exit is ______ K.

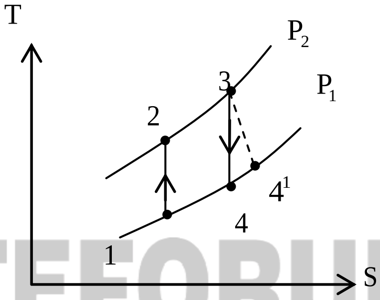
Key: **675 to 684**

Exp: $C_p = 1040 J/kg.K,\ r = 1.4$

$P_2/P_1 = 10,\ T_3 = 1200K$

$\eta_{is} = 0.9$

$\therefore$ Isentropic Expansion,



$$\left(\frac{P_3}{P_4}\right)^{\frac{r-1}{r}} = \left(\frac{T_3}{T_4}\right) \Rightarrow (10)^{0.4/1.4} = \frac{1200}{T_4}$$

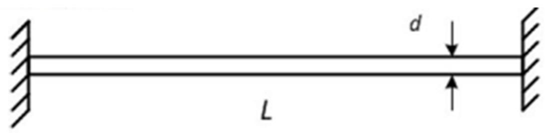
$T_4 = 621.5K$

$$\eta_{iso} = \frac{T_3 - T_4^1}{T_3 - T_4}$$

So, $T_4^1 = T_3 - \eta_{iso}(T_3 - T_4) = 1200 - 09(1200 - 621.5)$

$T_4 = 679.38K$

40. An initially stress-free massless elastic beam of length L and circular cross-section with diameter d ($d << L$) is held fixed between two walls as shown. The beam material has Young's modulus E and coefficient of thermal expansion α.

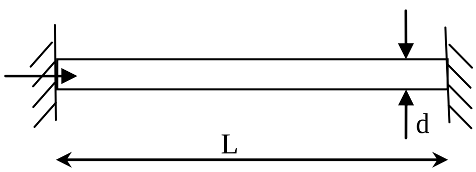


If the beam is slowly and uniformly heated, the temperature rise required to cause the beam to buckle is proportional to

(A) d (B) d^2 (C) d^3 (D) d^4

Key: **(B)**

Exp: $P(EA\alpha\Delta T) = \frac{\pi EI}{\ell_e^2}$



$$\Delta T = \frac{\pi}{\alpha} \times \frac{1}{\ell} \times \left(\frac{I}{A}\right)$$

$$\Delta T = \frac{\pi}{\alpha} \times \frac{1}{\ell} \times \frac{\frac{\pi}{64} d^4}{\frac{\pi}{4} d^2}$$

$\Delta T \propto d^2$

41. For the vector $\vec{V} = 2yz\hat{i} + 3xz\hat{j} + 4xy\hat{k}$, the value of $\nabla.\left(\nabla \times \vec{V}\right)$ is ____________

Key: **0 to 0**

Exp: $\vec{V} = 2yzi + 3xzj + 4xyk$

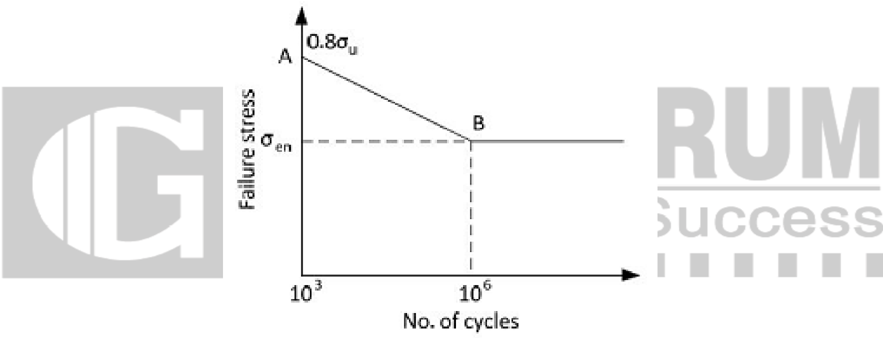
we know that $\nabla.(\nabla \times V) = 0$ for any vector V

42. A 10 mm deep cylindrical cup with diameter of 15mm is drawn from a circular blank. Neglecting the variation in the sheet thickness, the diameter (upto 2 decimal points accuracy) of the blank is _________ mm.

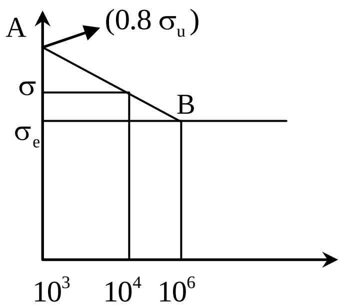
Key: **28.71 to 28.73**

Exp: $D = \sqrt{d^2 + 4dh} = \sqrt{15^2 + 4 \times 10 \times 15} = 28.72\text{ mm}$

43. A machine element has an ultimate strength (σ_u) of 600 N/mm^2, and endurance limit (σ_{en}) of 250 N/mm^2. The fatigue curve for the element on log-log plot is shown below. If the element is to be designed for a finite of 10000 cycles, the maximum amplitude of a completely reversed operating stress is _________ N/mm^2.



Key: **370 to 390**



Exp: $\sigma_u = 600\text{MPa}$

$\sigma_{en} = 250\text{MPa}$

$N = 10000 \text{ cycle}$

$$\frac{\log(0.8\sigma_u) - \log(250)}{3-6} = \frac{\log(0.8\sigma_u) - \log(\sigma)}{3-4}$$

$$\frac{\log(480) - \log(250)}{-3} = \frac{\log(480) - \log(\sigma)}{-1}$$

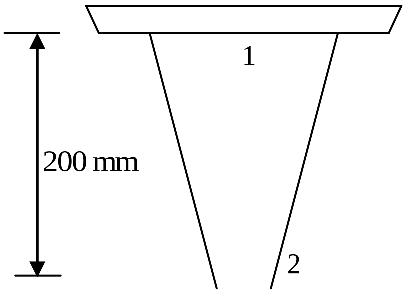
$$\log(\sigma) = \frac{3\log(480) - \log(480) + \log(250)}{3} = \frac{2\log(480) + \log(250)}{3}$$

$\sigma_{max} = 386.19\text{MPa}$

44. A sprue in a sand mould has a top diameter of 20mm and height of 200mm. The velocity of the molten metal at the entry of the sprue is 0.5m/s. Assume acceleration due to gravity as 9.8 m/s^2 and neglect all losses. If the mould is well ventilated, the velocity (upto 3 decimal points accuracy) of the molten metal at the bottom of the sprue is ________ m/s.

Key: **2.04 to 2.07**

Exp: Apply Bernoulli's between (1) and (2)



$$\frac{P_1}{\gamma}+\frac{V_1^2}{2g}+z_1=\frac{P_2}{\gamma}+\frac{V_2^2}{2g}+z_2$$

$$\frac{0.5^2}{2g}+0.2+\frac{V_2^2}{2g}$$

$$V_2=2.042\ m/s$$

45. Air contains 79% N_2 and 21% O_2 on a molar basis. Methane (CH_4) is burned with 50% excess air than required stoichiometrically. Assuming complete combustion of methane, the molar percentage of N_2 in the products is ________________

Key: **73 to 74**

Exp: Stoichiometric reaction $CH_4+2.\left[O_2+\frac{79}{21}N_2\right]\rightarrow 2H_2O+CO_2+2\times\frac{79}{21}\times N_2$

50% excess air

$$CH_4+3.\left[O_2+\frac{79}{21}N_2\right]\rightarrow 2H_2O+CO_2+3\times\frac{79}{21}\times N_2+O_2$$

$$\%N_2=\frac{\frac{3\times 79}{21}}{2+1+1+3\times\frac{79}{21}}\times 100=73.83\%$$

46. P(0,3), Q(0.5, 4), and R (1,5) are three points on the curve defined by f(x). Numerical integration is carried out using both Trapezoidal rule and Simpson's rule within limits x = 0 and x =1 for the curve. The difference between the two results will be.

(A) 0 (B) 0.25 (C) 0.5 (D) 1

Key: **(A)**

Exp: Let

x	0	0.5	1
y	3	4	5

Trapezoidal rule

$$\int_0^1 f(x)dx=\frac{0.5}{2}\left[(3+5)+2(4)\right]=\frac{0.5}{2}\times 16=4$$

Simpsons rule

$$\int_0^1 f(x)dx=\frac{0.5}{3}\left[(3+5)+0+4(4)\right]=\frac{0.5}{3}\times 24=4$$

Difference $=0$

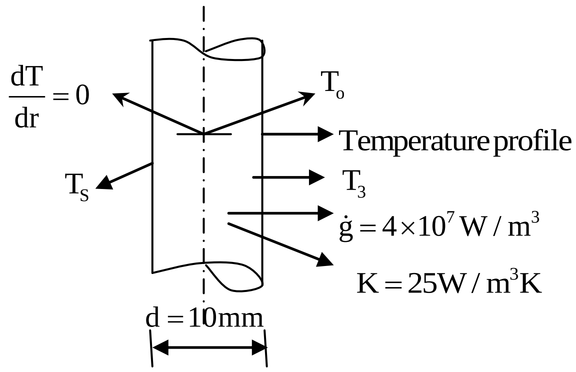
47. Heat is generated uniformly in a long solid cylindrical rod (diameter = 10mm) at the rate of 4×10^7 W/m^3. The thermal conductivity of the rod material is 25W/m.K. Under steady state conditions, the temperature difference between the centre and the surface of the rod is _________ °C.

Key: **10 to 10**

Exp: Given that, heat is generated uniformly i.e., $\dot{g} = 4\times10^7\ W/m^3$

Diameter at the rod (d) = 10 mm

Thermal conductivity of the rod (K) = 25 W/mK



W.K.T for steady state, with internal heat generation, the conduction equation will be,

$$\frac{1}{r}\frac{d}{dr}\left(r.\frac{dT}{dr}\right) + \frac{\dot{g}}{k} = 0$$

$$\Rightarrow \frac{d}{dr}\left(r\frac{dT}{dr}\right) + \frac{\dot{g}r}{K} = 0$$

After Integration once

$$r.\frac{dT}{dr} + \frac{\dot{g}r^2}{2K} = C_1 \Rightarrow \frac{dT}{dr} + \frac{\dot{g}r}{2K} = \frac{c_1}{r} \rightarrow (1)$$

After second Integration

$$T(r) + \frac{\dot{g}r^2}{4K} = C_1 \ell n(r) + C_2 \rightarrow (2)$$

Substituting boundary condition of $\frac{dT}{dr} = 0$ at $r = 0$ in eq(1)

That gives $C_1 = 0$

$$\Rightarrow T(r) + \frac{\dot{g}r^2}{4k} = C_2,$$ substitute at r =0, T(r) = T_o

$$\Rightarrow T_o + (o) = C_2 \Rightarrow C_2 = T_o$$

$$\therefore T(r) + \frac{\dot{g}r^2}{4K} = T_o$$

Substitute $r = r_o = \frac{10}{2} = 5mm = 0.005m$ and $T(r) = T_S$

The above equation will become

$$T_S + \frac{\dot{g}r_o^{\ 2}}{4K} = T_o$$

$$\Rightarrow T_o - T_s = \frac{4\times10^7\times0.005^2}{4\times25} = 10^\circ C$$

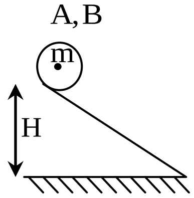
48. Two disks A and B with identical mass (m) and radius (R) are initially at rest. They roll down from the top of identical inclined planes without slipping. Disk A has all of its mass concentrated at the rim, while Disk B has its mass uniformly distributed. At the bottom of the plane, the ratio of velocity of the center of disk A to the velocity of the center of disk B is.

(A) $\sqrt{\frac{3}{4}}$ (B) $\sqrt{\frac{3}{2}}$ (C) 1 (D) $\sqrt{2}$

Key: **(A)**

Exp: $I_A = MR^2$

$$I_B = \frac{MR^2}{2}$$



$$P.E = [K.E_T + K.E_R]_A = [K.E_T + K.E_R]_B$$

$$= \frac{1}{2}MV_A^2 + \frac{1}{2}I\omega_A^2 = \frac{1}{2}MV_B^2 + \frac{1}{2}I\omega_B^2$$

$$= \frac{1}{2}MV_A^2 + \frac{1}{2}MR^2\omega_A^2 = \frac{1}{2}MV_B^2 + \frac{1}{2}\frac{MR^2}{2}\omega_B^2$$

$$V_A^2 + V_A^2 = V_B^2 + \frac{V_B^2}{2}$$

$$2V_A^2 = \frac{3}{2}V_B^2 \Rightarrow \frac{V_A}{V_B} = \sqrt{\frac{3}{4}}$$

49. A block of length 200mm is machined by a slab milling cutter 34mm in diameter. The depth of cut and table feed are set at 2mm and 18mm/minute, respectively. Considering the approach and the over travel of the cutter to be same, the minimum estimated machining time per pass is _____________ minutes.

Key: **12 to 12**

Exp: Milling Time $= \frac{2\times\sqrt{Dd - d^2} + L}{f} = \frac{2\times\sqrt{(34\times 2) - 2^2} + 200}{18} = 12$

Where, $D = $ Dia of cutter (mm), $d = $ depth of cut (mm)

$L = $ length $f = $ feed (mm/min)

50. A horizontal bar, fixed at one end (x = 0), has a length of 1 m, and cross-sectional area of $100mm^2$. Its elastic modulus varies along its length as given by $E(x) = 100e^{-x}$ GPa, Where x is the length coordinate (in m) along the axis of the bar. An axial tensile load of 10 kN is applied at the free end (x=1). The axial displacement of the free end is _______ mm.

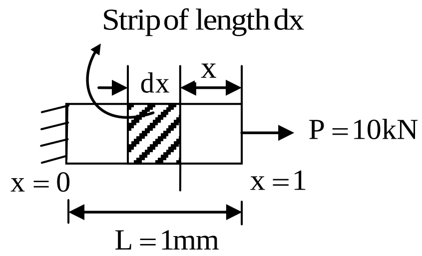
Key: 1.70 to 1.72

Exp: Given that

$$P = 10kN = 10\times 10^3 N, A = 100mm^2$$

$$E(x) = 100e^{-x} Gpa = \frac{100\times e^{-x}\times 10^9}{10^6} = 10^5 \times e^{-x}$$

Change in the length of small strip $\delta = \frac{P(dx)}{AE_x}$



Total change in the length of the bar $(\delta)=\int_0^L \frac{Pdx}{AE_x}$

$$\delta=\int_0^L \frac{P}{A}\frac{dx}{100e^{-x}}=\frac{P}{A\times10^5}\int_0^L \frac{dx}{e^{-x}}=\frac{P}{A\times10^5}\int_0^L e^x dx=\frac{P}{A\times10^5}\int_0^1 e^x dx=\frac{P}{A\times10^5}\left[e^1-1\right]$$

$$=\frac{10\times10^3}{100\times10^5}[2.7183-1]\times1000=1.7183\text{mm}$$

51. Consider steady flow of an incompressible fluid through two long and straight pipes of diameters d_1 and d_2 arranged in series. Both pipes are of equal length and the flow is turbulent in both pipes. The friction factor for turbulent flow though pipes is of the form, $f=K(Re)^{-n}$ where K and n are known positive constants and Re is the Reynolds number. Neglecting minor losses, the ratio of the frictional pressure drop in pipe 1 to that in pipe 2, $\left(\frac{\Delta P_1}{\Delta P_2}\right)$, is given by

(A) $\left(\frac{d_2}{d_1}\right)^{(5-n)}$ (B) $\left(\frac{d_2}{d_1}\right)^{5}$ (C) $\left(\frac{d_2}{d_1}\right)^{(3-n)}$ (D) $\left(\frac{d_2}{d_1}\right)^{(5+n)}$

Key: **(A)**

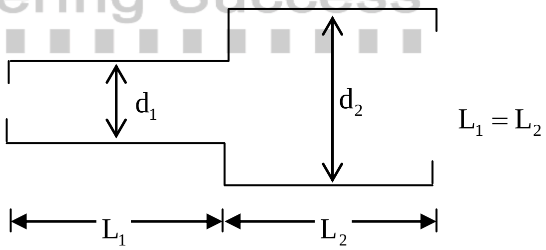
Exp: $\frac{\Delta P_1}{\Delta P_2}=\left(\frac{f_1L_1Q^2}{12d_1^5\rho g}\right)\left(\frac{12d_2^5\rho g}{f_2L_2Q^2}\right)=\frac{f_1}{f_2}\left(\frac{d_2}{d_1}\right)^5=\frac{(Re_1)^{-n}}{(Re_2)^{-n}}\left(\frac{d_2}{d_1}\right)^5$ ......(1) $\left(\because f=\frac{64}{Re}\right)$

$\because Re=\frac{V\rho d}{\mu}$ & $Q=AV=\frac{\pi}{4}d^2V\Rightarrow\left(V=\frac{4Q}{\pi d^2}\right)$

So, $Re=\frac{4Q}{\pi d^2}\times\frac{\rho d}{\mu}=\frac{4Q\rho}{\pi d\mu}$

$Re\propto\frac{1}{d}$ From(1) $\frac{\Delta P_1}{\Delta P_2}=\frac{d_1^{\,n}}{d_2^{\,n}}\left(\frac{d_2}{d_1}\right)^5$

$\frac{\Delta P_1}{\Delta P_2}=\left(\frac{d_2}{d_1}\right)^{5-n}$



52. The velocity profile inside the boundary layer for flow over a flat plate is given as $\frac{u}{U_\infty}=\sin\left(\frac{\pi}{2}\frac{y}{\delta}\right)$, where U_∞ is the free stream velocity and δ is the local boundary layer thickness. If $\delta*$ is the local displacement thickness, the value of $\frac{\delta*}{\delta}$ is

(A) $\frac{2}{\pi}$ (B) $1-\frac{2}{\pi}$ (C) $1+\frac{2}{\pi}$ (D) 0

Key: **(B)**

Exp: $\frac{U}{U_\infty}=\sin\left(\frac{\pi y}{2\delta}\right)$

displacement thickness

$$\delta^*=\int_0^\delta(1-U/U_\infty)dy=\left[1-\sin\frac{\pi y}{2\delta}\right]dy$$

$$\delta^* = \delta + \frac{\left[\cos(\pi y/2\delta)\right]_0^\delta}{(\pi/2\delta)}$$

$$\delta^* = \delta + \frac{2\delta}{\pi}\left[\cos\pi/2 - \cos 0\right]$$

$$\left[\delta^* = \delta - \frac{2\delta}{\pi}\right]$$

$$\left[\delta^*/\delta = 1 - 2/\pi\right]$$

53. For a steady flow, the velocity field is $\vec{V} = (-x^2+3y)\hat{i} + (2xy)\hat{j}$. The magnitude of the acceleration of a particle at (1, -1) is

(A) 2 (B) 1 (C) $2\sqrt{5}$ (D) 0

Key: (C)

Exp: $\vec{V} = (-x^2+3y)\hat{i} + (2xy)\hat{j}$

$U = -x^2 + 3y$

$V = 2xy$

$$a_x = U\frac{\partial U}{\partial x} + V\frac{\partial U}{\partial y} = (-x^2+3y)(-2x) + (2xy)3 = 2x^3 - 6xy + 6xy = 2x^3$$

$$a_y = U\frac{\partial V}{\partial x} + V\frac{\partial V}{\partial y} = (-x^2+3y)(2y) + (2xy)(2x) = -2x^2y + 6y^2 + 4x^2y = 2x^2y + 6y^2$$

but $x = 1, y = -1$

$a_x = 2$

$a_y = 2(1)^2(-1) + 6(-1)^2 = 6 - 2 = 4$

$a = \sqrt{a_x^2 + a_y^2} = \sqrt{4+16} = \sqrt{20}$

$a = 2\sqrt{5}$

54. Two cutting tools with tool life equations given below are being compared:

Tool 1: $VT^{0.1}=150$

Tool 2: $VT^{0.3}=300$

Where V is cutting speed in m/minute and T is tool life in minutes. The breakeven cutting speed beyond which Tool 2 will have a higher tool life is ________ m/minute.

Key: 105 to 107

Exp: At Breakeven point

$T_1 = T_2$

$$\left(\frac{150}{V}\right)^{1/0.1} = \left(\frac{300}{V}\right)^{1/0.3}$$

$V = 106.121\ \text{m/min}$

55. A rectangular region in a solid is in a state of plane strain. The (x,y) coordinates of the corners of the under deformed rectangle are given by P(0,0), Q (4,0), S (0,3). The rectangle is subjected to uniform strains, $\varepsilon_{xx} = 0.001, \varepsilon_{yy} = 0.002, \gamma_{xy} = 0.003$. The deformed length of the elongated diagonal, up to three decimal places, is _________ units.

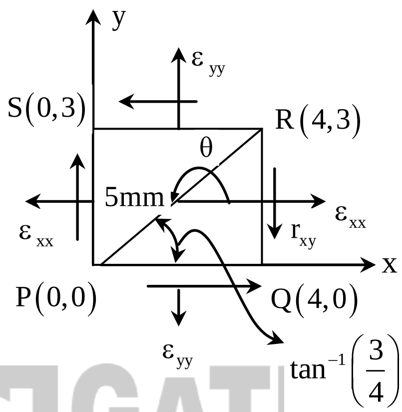
Key: 5.013 to 5.015

Exp: Given that

$\varepsilon_{xx} = 0.001, \varepsilon_{yy} = 0.002$

$r_{xy} = 0.003$

Length of the diagonal $(PR) = \sqrt{4^2 + 3^2} = 5m$



To find the diagonal (PR) strain, the direction of the plane angle from the +ve x-axis will from 'R' towards 'P'

$\varepsilon_\theta = ?$

Where $\theta = 180 + \tan^{-1}(3/4) = 216.87^o$

$$\varepsilon_{\theta=216.87^o} = \frac{\varepsilon_{xx} + \varepsilon_{yy}}{2} + \frac{\varepsilon_{xx} - \varepsilon_{yy}}{2}\cos 2\theta + \frac{r_{xy}}{2}\sin 2\theta$$

$$= \frac{0.001 + 0.002}{2} + \frac{0.001 - 0.002}{2}\cos(2 \times 216.87) + \frac{0.003}{2}\sin(2 \times 216.87^o)$$

$$= 0.0015 - 1.4 \times 10^{-4} + 1.44 \times 10^{-3}$$

$$= 2.8 \times 10^{-3}$$

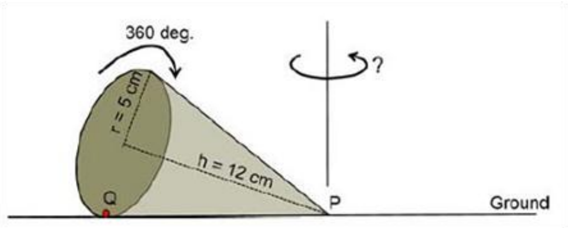
Elongation of the diagonal = $\varepsilon_{\theta=216.87} \times 5 = 2.8 \times 10^{-3} \times 5 = 0.014$

Defined length of diagonal $= 5 + 0.014 = 5.014$

General Aptitude

Q. No. 1 - 5 Carry One Mark Each

1. A right – angled cone (with base radius 5cm and height 12cm), as shown in the figure below, is rolled on the ground keeping the point P fixed until the point Q (at the base of the cone, as shown) touches the ground again.

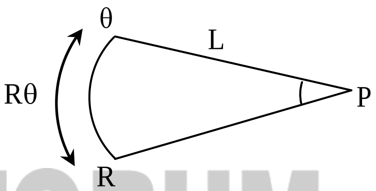


By what angle (in radians) about P does the cone travel?

(A) $\frac{5\pi}{12}$ (B) $\frac{5\pi}{24}$ (C) $\frac{24\pi}{5}$ (D) $\frac{10\pi}{13}$

Key: (D)

Exp: $L=\sqrt{5^2+12^2}=13cm$



Circumference of base circle = length of arc QR

$(2\pi r)=R\theta$ (R = Slant height of the Cone = 13 cm)

$(2\pi\times5)=13\theta$

$\theta=\frac{10\pi}{13}$

2. In a company with 100 employees, 45 earn Rs. 20,000 per month, 25 earn Rs. 30,000, 20 earn Rs. 40,000,8 earn Rs. 60,000, and 2 earn Rs. 150,000. The median of the salaries is

(A) Rs. 20,000 (B) Rs.30,000 (C) Rs. 32,300 (D) Rs. 40,000

Key: (B)

Exp: All the values put either in ascending or descending order first.

Now number of observations equal to 100 [even]

$\therefore$ The median of these values = Avg of two middle most observations.

$$=\frac{50^{th}\text{ observation}+51^{st}\text{observation}}{2}=\frac{30,000+30,000}{2}=30,000$$

3. As the two speakers became increasingly agitated, the debate became __________.

(A) lukewarm (B) poetic (C) forgiving (D) heated

Key: (D)

4. P,Q, and R talk about S's car collection. P states that S has at least 3 cars. Q believes that S has less than 3 cars. R indicates that to his knowledge, S has at least one Car. Only one of P, Q and R is right the number cars owned by S is.

(A) 0 (B) 1 (C) 3 (D) Cannot be determined

Key: (A)

Exp: P States that S has atleast 3 cars, i.e., ≥ 3

Q believes that S has less than 3 cars, i.e., <3

R indicates that S has atleast one car ≥ 1

P's and Q's statements are exactly opposite in nature and R's statement is proportional to P's statement.

From the given data, only one person statement is right as it mean that two persons statements are wrong, i.e., P and R wrong when S has zero cars.

5. He was one of my best __________ and I felt his loss _________.

(A) friend, keenly (B) friends, keen (C) friend, keener (D) friends, keenly

Key: (D)

Q. No. 6- 10 Carry Two Marks Each

6. Two very famous sportsmen Mark and Steve happened to be brothers, and played for country K. Mark teased James, an opponent from country E, "There is no way you are good enough to play for your country.'' James replied, "Maybe not, but at least I am the best player in my own family."

Which one of the following can be inferred from this conversation?

(A) Mark was known to play better than James

(B) Steve was known to play better than Mark

(C) James and Steve were good friends

(D) James played better than Steve

Key: (B)

7. "Here, throughout the early 1820s, Stuart continued to fight his losing battle to allow his sepoys to wear their caste-marks and their own choice of facial hair on parade, being again reprimanded by the commander-in-chief. His retort that 'A stronger instance than this of European prejudice with relation to this country has never come under my observations' had no effect on his superiors."

According to this paragraph, which of the statements below is most accurate?

(A) Stuart's commander – in chief was moved by this demonstration of his prejudice.

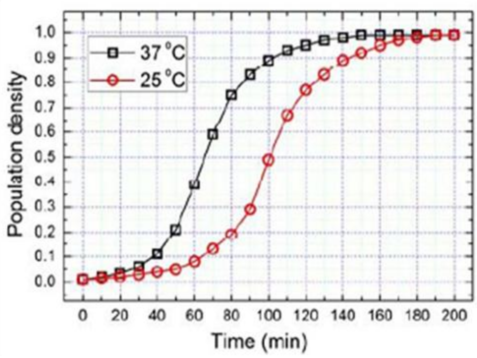
(B) The Europeans were accommodating of the sepoys' desire to wear their caste – marks.

(C) Stuart's losing battle' refers to his inability to succeed in enabling sepoys to wear caste-marks.

(D) The commander– in – Chief was exempt from the European preiudice that dictated how the sepoys were to dress.

Key: (C)

8. The growth of bacteria (lactobacillus) in milk leads to curd formation. A minimum bacterial population density of 0.8(in suitable units) is needed to form curd. In the graph below, the population density of lactobacillus in 1 litre of milk is plotted as a function of time, at two different temperatures, 25°C and 37°C.



Consider the following statements based on the data shown above:

(i) The growth in bacterial population stops earlier at 37°C as compared to 25°C

(ii) The time taken for curd formation at 25°C is twice the time taken at 37°C

Which one of the following options is correct?

(A) Only i (B) only ii (C) Both i and ii (D) Neither i nor ii

Key: **(A)**

Exp: From the graph, Statement (i) is correct,

The time taken for curd formation @25^o C= 120 min,

the time taken for curd formation @ 37^o C= 80 min, hence (ii) is incorrect.

9. Let S_1 be the plane figure consisting of the points (x,y) given by the inequalities $|x-1| \le 2$ and $|y+2| \le 3$. Let S_2 be the plane figure given by the inequalities $x - y \ge -2, y \ge 1,$ and $x \le 3$ Let S be the union of S_1 and S_2. The area of S is.

(A) 26 (B) 28 (C) 32 (D) 34

Key: **(C)**

10. What is the sum of the missing digits in the subtraction problem below?

$$\begin{array}{r} 5\_\ \_\ \_\ \_ \\ -4\,8\ \_\ 8\ 9 \\ \hline 1\,1\,1\,1 \end{array}$$

(A) 8 (B) 10 (C) 11 (D) Cannot be determined

Key: **(D)**