General Aptitude

Q. No. 1 – 5 Carry One Mark Each

1. Which of the following is **CORRECT** with respect to grammar and usage?
   Mount Everest is ____________.
   (A) the highest peak in the world
   (B) highest peak in the world
   (C) one of highest peak in the world
   (D) one of the highest peak in the world

Key: (A)

2. The policeman asked the victim of a theft, "What did you _____?"
   (A) loose (B) lose (C) loss (D) louse

Key: (B)

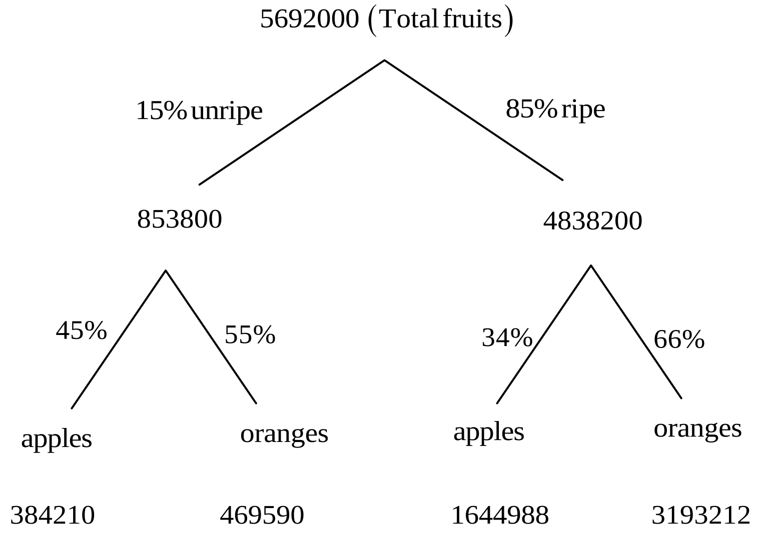
3. Despite the new medicine's____________in treating diabetes, it is not __________ widely.
   (A) effectiveness --- prescribed (B) availability --- used
   (C) prescription -- available (D) acceptance --- proscribed

Key: (A)

4. In a huge pile of apples and oranges, both ripe and unripe mixed together, 15% are unripe fruits. Of the unripe fruits, 45% are apples. Of the ripe ones, 66% are oranges. If the pile contains a total of 5692000 fruits, how many of them are apples?
   (A) 2029198 (B) 2467482 (C) 2789080 (D) 3577422

Key: (A)

Exp:



Total number of apples = 384210 + 1644988 = 2029198

5. Michael lives 10 km away from where I live. Ahmed lives 5 km away and Susan lives 7 km away from where I live. Arun is farther away than Ahmed but closer than Susan from where I live. From the information provided here, what is one possible distance (in km) at which I live from Arun's place?

(A) 3.00 (B) 4.99 (C) 6.02 (D) 7.01

Key: (C)

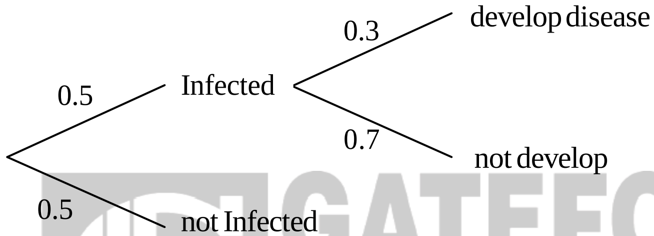
Q. No. 6 – 10 Carry Two Marks Each

6. A person moving through a tuberculosis prone zone has a 50% probability of becoming infected. However, only 30% of infected people develop the disease. What percentage of people moving through a tuberculosis prone zone remains infected but does not show symptoms of disease?

(A) 15 (B) 33 (C) 35 (D) 37

Key: (C)

Exp:



P(a person infected but does not show symptoms) $= 0.50 \times 0.70 = 0.35$

The percentage is 35%

7. In a world filled with uncertainty, he was glad to have many good friends. He had always assisted them in times of need and was confident that they would reciprocate. However, the events of the last week proved him wrong.

Which of the following inference(s) is/are logically valid and can be inferred from the above passage?

(i) His friends were always asking him to help them.

(ii) He felt that when in need of help, his friends would let him down.

(iii) He was sure that his friends would help him when in need.

(iv) His friends did not help him last week.

(A) (i) and (ii) (B) (iii) and (iv) (C) (iii) only (D) (iv) only

Key: (B)

8. Leela is older than her cousin Pavithra. Pavithra's brother Shiva is older than Leela. When Pavithra and Shiva are visiting Leela, all three like to play chess. Pavithra wins more often than Leela does.

Which one of the following statements must be **TRUE** based on the above?

(A) When Shiva plays chess with Leela and Pavithra, he often loses.

(B) Leela is the oldest of the three.

(C) Shiva is a better chess player than Pavithra.

(D) Pavithra is the youngest of the three.

Key: (D)

9. If $q^{-a} = \frac{1}{r}$ and $r^{-b} = \frac{1}{s}$ and $s^{-C} = \frac{1}{q}$, the value of abc is_____ .

(A) $(r\,q\,s)^{-1}$ (B) 0 (C) 1 (D) *r+q+s*

Key: (C)

Exp: $q^{-a} = \frac{1}{r}, r^{-b} = \frac{1}{s}, s^{-c} = \frac{1}{q}$

$q^a = r, r^b = s, s^c = q$

$r = q^a = \left(s^c\right)^a = s^{ac}$

$s = r^b = \left(s^{ac}\right)^b = s^{abc} \Rightarrow abc = 1$

10. **P**, **Q**, **R** and **S** are working on a project. **Q** can finish the task in 25 days, working alone for 12 hours a day. **R** can finish the task in 50 days, working alone for 12 hours per day. **Q** worked 12 hours a day but took sick leave in the beginning for two days. **R** worked 18 hours a day on all days. What is the ratio of work done by **Q** and **R** after 7 days from the start of the project?

(A) 10:11 (B) 11:10 (C) 20:21 (D) 21:20

Key: (C)

Exp: $\text{Q's one hour work} = \frac{1}{25\times12}$

$\text{R's one hour work} = \frac{1}{50\times12}$

Since Q has taken 2 days sick leave, he has worked only 5 days on the end of seventh day.

Work completed by Q on 7^{th} day= $(5\times12)\frac{1}{25\times12}$

Work completed by R on 7^{th} day= $(7\times18)\frac{1}{50\times12}$

$\text{Ratio of their work} = \frac{5\times12}{25\times12} \Big/ \frac{7\times18}{50\times12} = \frac{20}{21} \Rightarrow 20:21$

Mechanical Engineering

Q. No. 1 – 25 Carry One Mark Each

1. The solution to the system of equations

$$\begin{bmatrix} 2 & 5 \\ -4 & 3 \end{bmatrix}\begin{Bmatrix} x \\ y \end{Bmatrix} = \begin{Bmatrix} 2 \\ -30 \end{Bmatrix} \text{ is}$$

(A) 6, 2 (B) −6, 2 (C) −6, −2 (D) 6, −2

Key: (D)

Exp: By verification method; $\begin{bmatrix} 2 & 5 \\ -4 & 3 \end{bmatrix}\begin{bmatrix} 6 \\ -2 \end{bmatrix} = \begin{Bmatrix} 2 \\ 30 \end{Bmatrix}$

2. If f(t) is a function defined for all $t \geq 0$, its Laplace transform $F(s)$ is defined as

(A) $\int_0^\infty e^{st} f(t)dt$ (B) $\int_0^\infty e^{-st} f(t)dt$

(C) $\int_0^\infty e^{ist} f(t)dt$ (D) $\int_0^\infty e^{-ist} f(t)dt$

Key: (B)

Exp: Definition of Laplace transform of $f(t) \forall\ t \geq 0$.

3. f(z)=u(x,y)+iv(x,y) is an analytic function of complex variable z=x+iy where $i = \sqrt{-1}$. If u(x,y)=2xy, then v(x,y) may be expressed as

(A) $-x^2 + y^2 +$ constant (B) $x^2 - y^2 +$ constant

(C) $x^2 + y^2 +$ constant (D) $-(x^2 + y^2) +$ constant

Key: (A)

Exp: Given $u(x,y) = 2xy$

By total derivative definition; we have

$$dv = \frac{\partial v}{\partial x}dx + \frac{dv}{\partial y}dy$$

$$= \frac{-\partial u}{\partial y}dx + \frac{\partial u}{\partial x}dy \qquad [\because \text{by C} - \text{R equations}] \qquad \ldots (1)$$

$$\therefore \quad u(x,y) = 2xy \Rightarrow \frac{\partial u}{\partial x} = 2y; \frac{\partial u}{\partial y} = 2x$$

$$\text{From (1)}\ dv = -2xdx + 2ydy \qquad \ldots (2)$$

$$\Rightarrow V = -2\left(\frac{x^2}{2}\right) + 2\left(\frac{y^2}{2}\right) + \text{constant} \qquad (\because \text{equation 2 is exact D.E})$$

$$\Rightarrow V = -x^2 + y^2 + \text{constant}$$

4. Consider a Poisson distribution for the tossing of a biased coin. The mean for this distribution is μ. The standard deviation for this distribution is given by

(A) $\sqrt{\mu}$ (B) μ^2 (C) μ (D) $1/\mu$

Key: (A)

Exp: Given mean of a poisson distribution for the tossing of a biased coin is μ.

We know that Mean = Variance = μ

$\therefore$ Standard deviation $= \sqrt{\text{variance}} = \sqrt{\mu}$.

5. Solve the equation $x = 10\cos(x)$ using the Newton-Raphson method. The initial guess is $x = \pi/4$. The value of the predicted root after the first iteration, up to second decimal, is __________

Key: 1.56

Exp: By Newton-Raphson method; the iterative formula for finding approximate root at $(n+1)^{th}$ iteration is

$$x_{n+1} = x_n - \frac{f(x_n)}{f'(x_n)}; \text{ where } x = 0, 1, 2 \ldots\ldots$$

Putting n = 0; then

$$x_1 = x_0 - \frac{f(x_0)}{f'(x_0)} \quad \ldots (1)$$

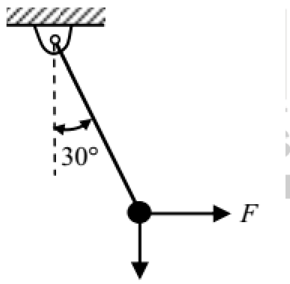
Let $f(x) = x - 10\cos x \Rightarrow f(x_0) = f\left(\frac{\pi}{4}\right) = \frac{\pi}{4} - \frac{10}{\sqrt{2}}.$

$\Rightarrow f'(x) = 1 + 10\sin x$

From (1); $\Rightarrow f'(x_0) = f'\left(\frac{\pi}{4}\right) = 1 + \frac{10}{\sqrt{2}}$

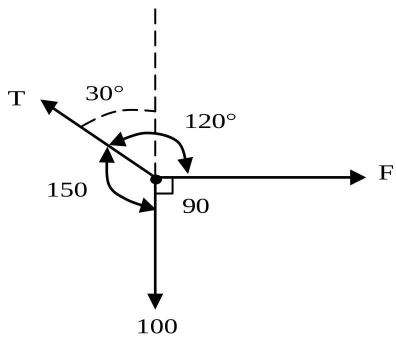
$$\therefore \quad x_1 = \frac{\pi}{4} - \left[\frac{\frac{\pi}{4} - \frac{10}{\sqrt{2}}}{1 + \frac{10}{\sqrt{2}}}\right] \cong 1.56$$

6. A rigid ball of weight 100 N is suspended with the help of a string. The ball is pulled by a horizontal force F such that the string makes an angle of 30^o with the vertical. The magnitude of force F (in N) is ____________.



Key: 57.735

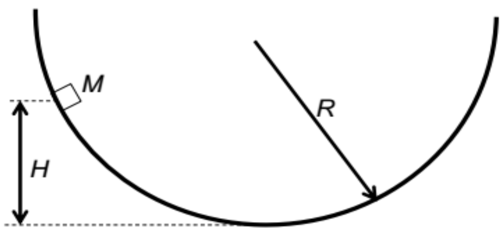
Exp: Applying Lami's theorem



$$\frac{T}{\sin 90} = \frac{100}{\sin(90+30)} = \frac{F}{\sin(180-30)}$$

$$F = 57.735 \text{ N}$$

7. A point mass M is released from rest and slides down a spherical bowl (of radius R) from a height H as shown in the figure below. The surface of the bowl is smooth (no friction). The velocity of the mass at the bottom of the bowl is



(A) $\sqrt{gH}$ (B) $\sqrt{2gR}$ (C) $\sqrt{2gH}$ (D) 0

Key: (C)

Exp: Since there is no friction. Therefore there will be no loss of energy of system. Hence energy remains conserved.

$P.E_1 + K.E_1 = P.E_2 + K.E_2$

$$mgH + \frac{1}{2}m(0)^2 = mg \times 0 + \frac{1}{2}mV_b^2$$

$$V_b = \sqrt{2gH}$$

8. The cross sections of two hollow bars made of the same material are concentric circles as shown in the figure. It is given that $r_3 > r_1$ and $r_4 > r_2$, and that the areas of the cross-sections are the same. J_1 and J_2 are the torsional rigidities of the bars on the left and right, respectively. The ratio J_2/J_1 is

(A) > 1 (B) < 0.5 (C) =1 (D) between 0.5 and 1

Key: (A)

Exp:

Smaller Ring (1) Bigger Ring (2)

Given $A_1 = A_2$

$$\pi\left(r_2^2 - r_1^2\right) = \pi\left(r_4^2 - r_3^2\right)$$

$$r_2^2 - r_1^2 = r_4^2 - r_3^2 \quad \underline{\qquad\qquad}(1)$$

We know , Torsional Rigidity = J= Shear Modulus× Polar moment of Inertia

$$\Rightarrow \frac{J_2}{J_1} = \frac{G \times \frac{\pi}{2}\left(r_4^4 - r_3^4\right)}{G \times \frac{\pi}{2}\left(r_2^4 - r_1^4\right)} \Rightarrow \frac{J_2}{J_1} = \frac{\left(r_4^2 - r_3^2\right)}{\left(r_2^2 - r_1^2\right)} \times \frac{\left(r_3^2 + r_4^2\right)}{\left(r_1^2 + r_2^2\right)} = \frac{\left(r_3^2 + r_4^2\right)}{\left(r_1^2 + r_2^2\right)}$$

But, $r_4 > r_2$ and $r_3 > r_1$

$$\Rightarrow \frac{J_2}{J_1} > 1$$

9. A cantilever beam having square cross-section of side *a* is subjected to an end load. If *a* is increased by 19%, the tip deflection decreases approximately by

(A) 19% (B) 29% (C) 41% (D) 50%

Key: (D)

Exp: $\delta = \frac{p\ell^3}{3EI} \Rightarrow \delta \alpha \frac{1}{I} \Rightarrow \delta \alpha \frac{1}{a^4}$

$\frac{\delta_1}{\delta_2} = \frac{a_2^4}{a_1^4}$ where, $a_2 = 1.19a$,

$\Rightarrow \frac{\delta_1}{\delta_2} = (1.19)^4 \Rightarrow \delta_2 = \frac{\delta_1}{(1.19)^4} = 0.5\delta_1$

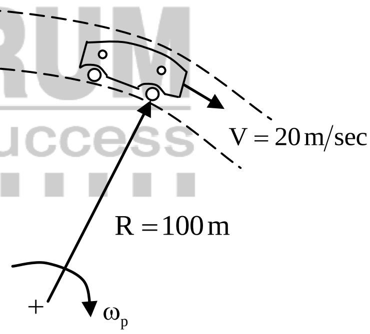
So, deflection decrease by 50%

10. A car is moving on a curved horizontal road of radius 100 m with a speed of 20 m/s. The rotating masses of the engine have an angular speed of 100 rad/s in clockwise direction when viewed from the front of the car. The combined moment of inertia of the rotating masses is 10 kg-m^2. The magnitude of the gyroscopic moment (in N-m) is ___________.

Key: 200

Exp: **Given:** Spin velocity (ω_s)= 100 rad/sec

Moment of Inertia (MOI) = 10 kg-m^2



Precision Angular Velocity $(\omega_p) = \frac{\text{linear speed}}{R}$

$= \frac{20}{100} = 0.2$ rad/sec

Gyroscopic moment = MOI $\omega_s \times \omega_p$

$= 10 \times 100 \times 0.2$

$= 200\,Nm$

11. A single degree of freedom spring mass system with viscous damping has a spring constant of 10 kN/m. The system is excited by a sinusoidal force of amplitude 100 N. If the damping factor (ratio) is 0.25, the amplitude of steady state oscillation at resonance is ________mm.

Key: 20

Exp: **Given:** Spring constant (k) = 10 kN/m = 10,000 N/m

Magnitude of force (F_0) = 100N

Damping factor $(\xi) = 0.25$

Forcing frequency (ω) = Natural frequency (ω_n)

Static deflection of spring $= \frac{F_0}{k} = \frac{100}{10^4} = 10^{-2}\,m$

$= 10\,mm$

$$\text{Dynamic deflection} = \frac{\text{Static deflection}}{\sqrt{\left[1-\left(\frac{\omega}{\omega_n}\right)^2\right]^2+\left(2\xi\frac{\omega}{\omega_n}\right)^2}}$$

$$= \frac{10}{\sqrt{\left(1-(1)^2\right)^2+(2\times 0.25\times 1)^2}}$$

$$= \frac{10}{2\times 0.25} = 20\,\text{mm}$$

12. The spring constant of a helical compression spring DOES NOT depend on

(A) coil diameter

(B) material strength

(C) number of active turns

(D) wire diameter

Key: (B)

Exp: For Helical compression spring.

$$\text{Deflection, } \delta = \frac{64\,WR^3 n}{Gd^4}$$

$$\text{Stiffness, or spring constant } = \frac{W}{\delta} = \frac{W}{\frac{64\,WR^3 n}{Gd^4}} = \frac{Gd^4}{64R^3 n}$$

From the above formula we can say that spring constant depends on coil diameter (D), wire diameter (d), No. of active turns (n) and modulus of rigidity (G) and is independent of material strength.

13. The instantaneous stream-wise velocity of a turbulent flow is given as follows:

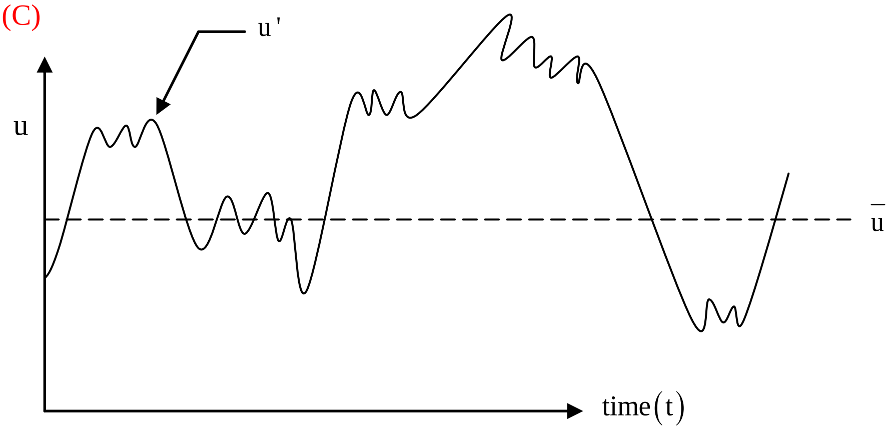
$u(x, y, z, t) = \bar{u}(x, y, z) + u'(x, y, z, t)$

The time-average of the fluctuating velocity $u'(x, y, z, t)$ is

(A) $u'/2$ (B) $-\bar{u}/2$ (C) zero (D) $\bar{u}/2$

Key: (C)

Exp:



Given $u = \bar{u} + u'$ ______(1)

where $\bar{u} = \frac{1}{T}\int_0^T u\,dt$ T = period after which pattern will repeat

Rewriting equation (1)

$$u' = u - \bar{u}$$

taking average of fluctuating component

$$\overline{u'} = \frac{1}{T}\int_0^T u'dt \quad = \frac{1}{T}\int_0^T \left(u - \bar{u}\right)dt \quad = \frac{1}{T}\int_0^T u\,dt - \frac{1}{T}\int_0^T \bar{u}\,dt \quad = \bar{u} - \bar{u}\left(\frac{1}{T}\int_0^T dt\right)$$

$$= \bar{u} - \bar{u}$$

$$\overline{u'} = 0$$

14. For a floating body, buoyant force acts at the

(A) centroid of the floating body

(B) center of gravity of the body

(C) centroid of the fluid vertically below the body

(D) centroid of the displaced fluid

Key: (D)

15. A plastic sleeve of outer radius r_0 = 1 mm covers a wire (radius r = 0.5 mm) carrying electric current. Thermal conductivity of the plastic is 0.15 W/m-K. The heat transfer coefficient on the outer surface of the sleeve exposed to air is 25 W/m^2-K. Due to the addition of the plastic cover, the heat transfer from the wire to the ambient will

(A) increase

(B) remain the same

(C) decrease

(D) be zero

Key: (A)

Exp: Given

$r_0 = 1\text{mm}$

$r = 0.5\,\text{mm}$

$K = 0.15\,\text{W/mK}$

$h = 25\,\text{W/m}^2\text{K}$

$$\text{Critical radius} = k/h = \frac{0.15}{25} = 6\,\text{mm}$$

So radius of wire is less than critical radius, addition of plastic sleeve will increase the heat transfer.

16. Which of the following statements are TRUE with respect to heat and work?

(i) They are boundary phenomena

(ii) They are exact differentials

(iii) They are path functions

(A) both (i) and (ii) (B) both (i) and (iii) (C) both (ii) and (iii) (D) only (iii)

Key: (B)

17. Propane (C_3H_8) is burned in an oxygen atmosphere with 10% deficit oxygen with respect to the stoichiometric requirement. Assuming no hydrocarbons in the products, the volume percentage of CO in the products is ____

Key: 14.286

Exp: $C_3H_8 + 5(0.9)O_2 + 5(3.76)0.9N_2 \rightarrow aCO + bCO_2 + 4H_2O + 16.92N_2$

$\text{Carbon balance}: 3 = a + b$

$\text{Qxygen balance}: \underline{9 = a + 2b + 4}$

$\underline{-6 = -b - 4}$

$a = 1, b = 2$

$\frac{1}{7} \times 100 = 14.286\%$

18. Consider two hydraulic turbines having identical specific speed and effective head at the inlet. If the speed ratio (N_1/N_2) of the two turbines is 2, then the respective power ratio (P_1/P_2) is ____.

Key: 0.25

Exp: Given: Specific speed of Turbine "1" (N_{S1}) = Specific Speed of Turbine "2" (N_{S2})

Effective Head at inlet of Turbine "1" (H_1) = Effective head at inlet of turbine "2" (H_2)

and $N_1/N_2 = 2$

Specific Speed of Turbine $(N_S) = \frac{N\sqrt{P}}{H^{5/4}}$

$N_{S1} = N_{S2}$

$$\frac{N_1\sqrt{P_1}}{H_1^{5/4}} = \frac{N_2\sqrt{P_2}}{H_2^{5/4}}$$

$$\frac{P_1}{P_2} = \left(\frac{N_2}{N_1}\right)^2 = \left(\frac{1}{2}\right)^2 = \frac{1}{4} = 0.25$$

19. The INCORRECT statement about regeneration in vapor power cycle is that

(A) it increases the irreversibility by adding the liquid with higher energy content to the steam generator

(B) heat is exchanged between the expanding fluid in the turbine and the compressed fluid before heat addition

(C) the principle is similar to the principle of Stirling gas cycle

(D) it is practically implemented by providing feed water heaters

Key: **(A)**

20. The "Jominy test" is used to find

(A) Young's modulus
(B) hardenability
(C) yield strength
(D) thermal conductivity

Key: **(B)**

21. Under optimal conditions of the process the temperatures experienced by a copper work piece in fusion welding, brazing and soldering are such that

(A) $T_{welding} > T_{soldering} > T_{brazing}$ (B) $T_{soldering} > T_{welding} > T_{brazing}$

(C) $T_{brazing} > T_{welding} > T_{soldering}$ (D) $T_{welding} > T_{brazing} > T_{soldering}$

Key: (D)

22. The part of a gating system which regulates the rate of pouring of molten metal is

(A) pouring basin (B) runner (C) choke (D) ingate

Key: (C)

23. The non-traditional machining process that essentially requires vacuum is

(A) electron beam machining (B) electro chemical machining

(C) electro chemical discharge machining (D) electro discharge machining

Key: (A)

Exp: Electron beam machining requires vacuum, to avoid deflection of electrons

24. In an orthogonal cutting process the tool used has rake angle of zero degree. The measured cutting force and thrust force are 500 N and 250 N, respectively. The coefficient of friction between the tool and the chip is __________

Key: 0.5

Exp: $\text{Tan}(\beta - \alpha) = \dfrac{F_t}{F_C}$

$\text{Tan}(\beta - 0) = \dfrac{250}{500}$

$\text{Tan}\beta = \frac{1}{2} = 0.5$

25. Match the following:

P. Feeler gauge	I. Radius of an object
Q. Fillet gauge	II. Diameter within limits by comparison
R. Snap gauge	III. Clearance or gap between components
S. Cylindrical plug gauge	IV. Inside diameter of straight hole

(A) P–III, Q–I, R–II, S–IV (B) P–III, Q–II, R–I, S–IV

(C) P–IV, Q–II, R–I, S–III (D) P–IV, Q–I, R–II, S–III

Key: (A)

Exp: Feeler gauge: Clearance or gap between components

Fillet gauge: Radius of an object

Snap gauge: Diameter within limits by comparison

Cylindrical plug gauge: Inside diameter of straight hole.

Q. No. 26 – 55 carry Two Marks Each

26. Consider the function $f(x) = 2x^3 - 3x^2$ in the domain [−1, 2]. The global minimum of f(x) is ______

Key: -5

Exp: Given that, $f(x) = 2x^3 - 3x^2$

$\Rightarrow f'(x) = 0 \Rightarrow 6x^2 - 6x = 0$

$\Rightarrow x^2 - x = 0 \Rightarrow x(x-1) = 0$

$\Rightarrow x = 0; x = 1$

are Stationary points.

$\therefore \quad f''(x) = 12x - 6$

$\quad f''(0) = -6 > 0$

$\therefore$ f(x) has maximum at x = 0.

$f''(1) = 12(1) - 6 = 6 > 0$

$\therefore$ f(x) has minimum at x = 1.

$\therefore \quad f(1) = 2 - 3 = -1 \rightarrow$ local minimum value

But $f(-1) = -2 - 3 = -5$

$\therefore$ Global minimum of f(x) = -5

27. If $y = f(x)$ satisfies the boundary value problem $y'' + 9y = 0$, $y(0) = 0$, $y(\pi/2) = \sqrt{2}$, , then $y(\pi/4)$ is ______

Key: -1

Exp: Given D.E is $y'' + 9y = 0$

$\Rightarrow (D^2 + 9)y = 0$

The A.E is $D^2 + 9 = 0$

$\Rightarrow D^2 = -9 \Rightarrow D = \pm 3i$

$\therefore \quad y = c_1 \cos 3x + c_2 \sin 3x \qquad \ldots (1)$

Given

$y(0) = 0$ and $y(\pi/2) = \sqrt{2}$

i.e; $x = 0, y = 0$; i.e; $x = \pi/2; y = \sqrt{2}$

From(1); $\boxed{0 = C_1}$; From(1); $\sqrt{2} = 0 + C_2(-1)$

$\Rightarrow \boxed{C_2 = -\sqrt{2}}$

$\therefore$ From (1); $y = -\sqrt{2}\sin 3x$

$$\therefore \quad y\left(\frac{\pi}{4}\right) = -\sqrt{2}\sin\left(\frac{3\pi}{4}\right) = -\sqrt{2}\left(\frac{1}{\sqrt{2}}\right) = -1$$

$$\therefore \quad y\left(\frac{\pi}{4}\right) = -1$$

28. The value of the integral

$$\int_{-\infty}^{\infty} \frac{\sin x}{x^2+2x+2}dx$$

evaluated using contour integration and the residue theorem is

(A) $-\pi\sin(1)/e$ (B) $-\pi\cos(1)/e$ (C) sin(1)/e (D) cos(1)/e

Key: (A)

Exp: We know that sin x is the imaginary part of e^{ix}

$\therefore$ We consider the function $f(z)=\dfrac{e^{iz}}{z^2+2z+2}$

Now, the poles of f(z) are given by $z^2+2z+2=0$

$$\Rightarrow z=\frac{-2\pm\sqrt{4-4(2)}}{2}=\frac{-2\pm\sqrt{-4}}{2}$$

$$=\frac{-2\pm i2}{2}=-1\pm i$$

But $Z=-1+i$ is the only pole (simple) lie in the upper half of the Z-plane.

$$\therefore \quad \operatorname*{Res}_{z=-1+i} f(z)=\operatorname*{Lt}_{z\to(-1+i)}\left[z-(-1+i)\right].\frac{e^{iz}}{\left[z-(-1+i)\right]\left[z-(-1-i)\right]}$$

$$=\operatorname*{Lt}_{z\to-1+i}\frac{e^{iz}}{z+(1+i)}=\frac{e^{i(-1+i)}}{-1+i+1+i}=\frac{e^{-i-1}}{2i}=\frac{e^{-i}}{2ie}$$

Thus $\displaystyle\int_e \frac{e^{iz}}{z^2+2z+2}dz=2\pi i\left[\frac{e^{-i}}{2ie}\right]=\frac{\pi e^{-i}}{e}$

Equating imaginary parts on both sides we get

$$\int_e \frac{\sin z}{z^2+2z+2}dz=\frac{\pi(-\sin(1))}{e}=\frac{-\pi\sin(1)}{e}$$

29. Gauss-Seidel method is used to solve the following equations (as per the given order):

$$x_1+2x_2+3x_3=5$$
$$2x_1+3x_2+x_3=1$$
$$3x_1+2x_2+x_3=3$$

Assuming initial guess as $x_1=x_2=x_3=0$, the value of x_3 after the first iteration is ——

Key: -6

Exp: $x_1^{(1)}-0-0=5$ ...(1)

$2x_1^{(1)}+3x_2^{(1)}+0=1$ ...(2)

$3x_1^{(1)}+2x_2^{(1)}+x_3^{(1)}=3$ ...(3)

$\therefore$ From equation (1) $x_1^{(1)}=5$

From equation (2), $2x_1^{(1)}+3x_2^{(1)}=1$

$= 3x_2^{(1)}=1-2x_1^{(1)}$

$= 1-2(5)$

$\Rightarrow 3x_2^{(1)}=-9$

$\Rightarrow x_2^{(1)}=\frac{-9}{3}=-3 \Rightarrow x_2^{(1)}=-3$

From equation (3), $x_3^{(1)} = 3-3x_1^{(1)}-2x_2^{(1)}$

$=3-3(5)-2(-3)$

$=3-15+6=-6$

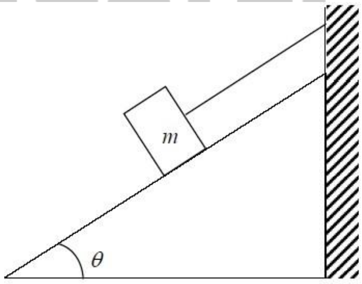
$\Rightarrow x_3^{(1)}=-6$

$\therefore$ After the first iteration, the value of x_3 is -6.

30. A block of mass m rests on an inclined plane and is attached by a string to the wall as shown in the figure. The coefficient of static friction between the plane and the block is 0.25. The string can withstand a maximum force of 20 N. The maximum value of the mass (m) for which the string will not break and the block will be in static equilibrium is ____________ kg.

Take $\cos\theta = 0.8$ and $\sin\theta = 0.6$.

Acceleration due to gravity g = 10 m/s²



Key: 5

Exp: $F=\mu R=\mu mg\cos\theta$

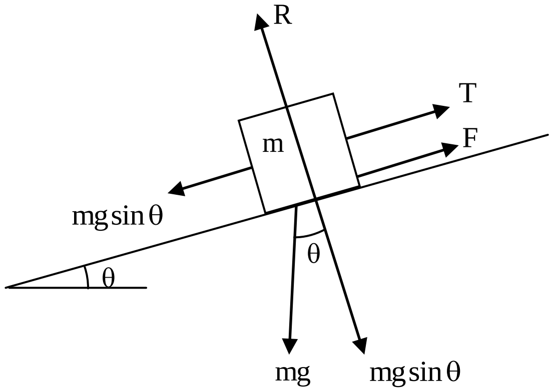
$=0.25\times m\times 10\times 0.8$

$=2m$

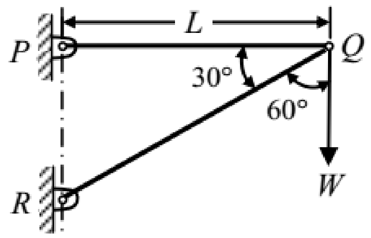
For equilibrium,

$T+F=mg\sin\theta$

$\Rightarrow 20+2m=m\times 10\times 0.6 \Rightarrow m=5\text{kg}$



31. A two-member truss *PQR* is supporting a load *W*. The axial forces in members *PQ* and *QR* are respectively



(A) $2W$ tensile and $\sqrt{3}W$ compressive

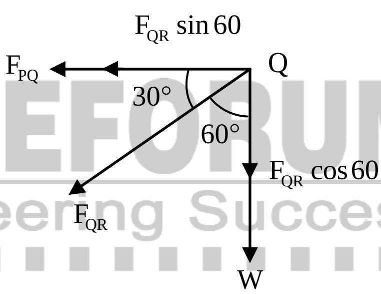
(B) $\sqrt{3}W$ tensile and $2W$ compressive

(C) $\sqrt{3}W$ compressive and $2W$ tensile

(D) $2W$compressive and $\sqrt{3}W$ tensile

Key: (B)

Exp: F.B.D of point Q



$\Sigma F_x = 0$

$\Rightarrow F_{PQ} + F_{QR}\sin 60 = 0 \;......\; (1)$

$\Sigma F_y = 0$

$\Rightarrow F_{QR}\cos 60 + W = 0 \;....(2)$

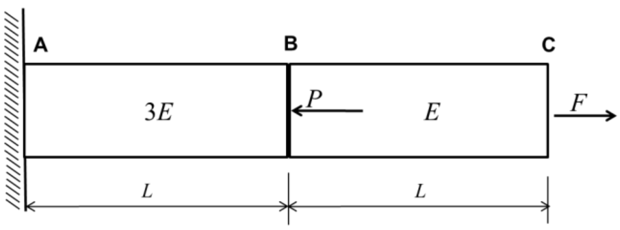
$\Rightarrow F_{QR} = \dfrac{-W}{\cos 60} \Rightarrow F_{QR} = 2W\left(\text{compressive}\right)$

From equation (1)

$F_{PQ} - 2W\sin 60 = 0$

$\Rightarrow F_{PQ} = 2W \times \dfrac{\sqrt{3}}{2} = \sqrt{3}W\;\left(\text{Tensile}\right)$

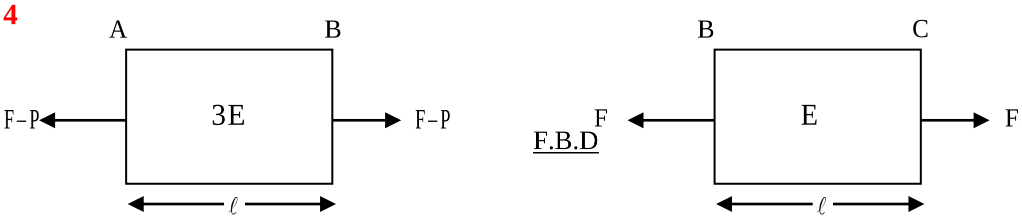
32. A horizontal bar with a constant cross-section is subjected to loading as shown in the figure. The Young's moduli for the sections AB and BC are 3*E* and *E*, respectively.



For the deflection at C to be zero, the ratio *P*/*F* is ______________

Key: 4

Exp:



Since, net deflection at C is zero

$\therefore \delta_{AB} + \delta_{BC} = 0$

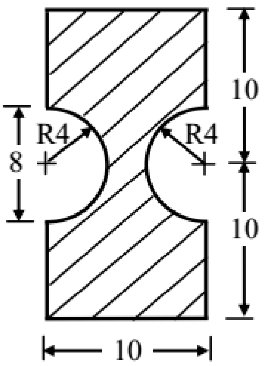
$\Rightarrow \dfrac{(F-P)\ell}{A.3E} + \dfrac{F\ell}{AE} = 0$

$\Rightarrow \dfrac{F-P}{3} + F = 0$

$\Rightarrow 4F - P = 0$

$\Rightarrow \dfrac{P}{F} = 4$

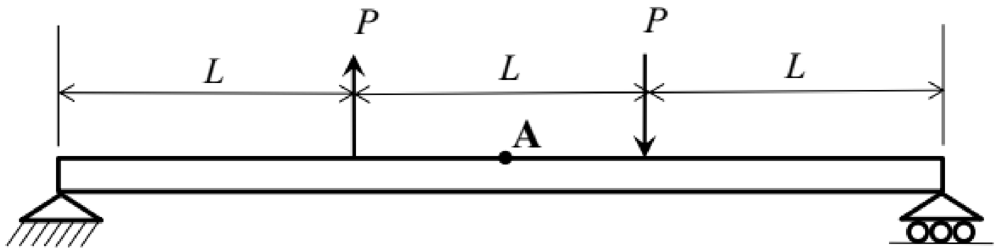
33. The figure shows cross-section of a beam subjected to bending. The area moment of inertia (in mm^4) of this cross-section about its base is _________.



All dimensions are in mm

Key: 1873 - 1879

34. A simply-supported beam of length 3*L* is subjected to the loading shown in the figure.

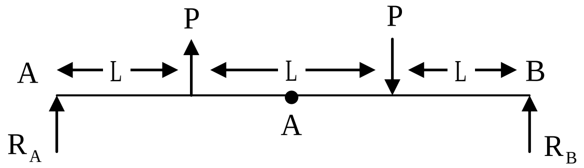


It is given that $P = 1$ N, $L = 1$ m and Young's modulus $E = 200$ GPa. The cross-section is a square with dimension 10 mm × 10 mm. The bending stress (in Pa) at the point **A** located at the top surface of the beam at a distance of 1.5*L* from the left end is ___

(Indicate compressive stress by a negative sign and tensile stress by a positive sign.)

Key: 0

Exp:



Taking moment about B

$\Sigma M_B = 0 \Rightarrow R_A \times 3L + P \times 2L - PL = 0 \Rightarrow R_A = -P/3$

$$\Sigma F_y = 0 \Rightarrow R_B + R_A = 0 \Rightarrow R_B = P/3$$

Taking moment about A

$$\Sigma M_A = 0$$

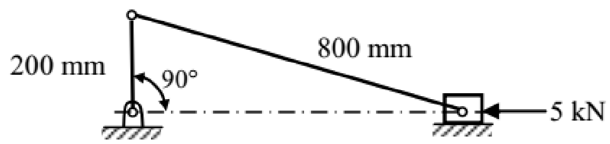
$$R_A \times 1.5L + 0.5PL = M_A \qquad (\text{Assuming } M_A \text{ anticlockwise})$$

$$\Rightarrow -\frac{P}{3} \times 1.5L + 0.5PL = M_A$$

$$\Rightarrow M_A = 0$$

$$\text{we know, } \frac{M}{I} = \frac{\sigma_b}{y} \Rightarrow \sigma_b \ (\text{Bending stress}) = 0 \qquad \text{since, } M_A = 0$$

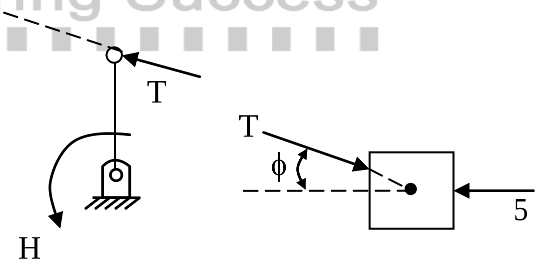
35. A slider crank mechanism with crank radius 200 mm and connecting rod length 800 mm is shown. The crank is rotating at 600 rpm in the counterclockwise direction. In the configuration shown, the crank makes an angle of 90^o with the sliding direction of the slider, and a force of 5 kN is acting on the slider. Neglecting the inertia forces, the turning moment on the crank (in kN-m) is _____



Key: 1

Exp: $T\cos\phi = 5$

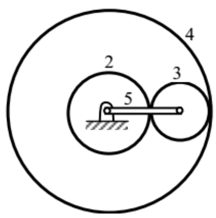
$$\text{Moment about crank shaft } (M) = T \times r\sin(90 - \phi)$$
$$= (T\cos\phi)r$$
$$= 5 \times 0.2$$
$$= 1\,\text{kN/m}$$



Alternate method:

$$M = 5 \times 0.2\left[\sin(90) + \frac{\lambda}{2}\sin(180)\right]$$
$$= 1\,\text{kN/m}$$

36. In the gear train shown, gear 3 is carried on arm 5. Gear 3 meshes with gear 2 and gear 4. The number of teeth on gear 2, 3, and 4 are 60, 20, and 100, respectively. If gear 2 is fixed and gear 4 rotates with an angular velocity of 100 rpm in the counterclockwise direction, the angular speed of arm 5 (in rpm) is



(A) 166.7 counterclockwise (B) 166.7 clockwise

(C) 62.5 counterclockwise (D) 62.5 clockwise

Key: (C)

Exp:

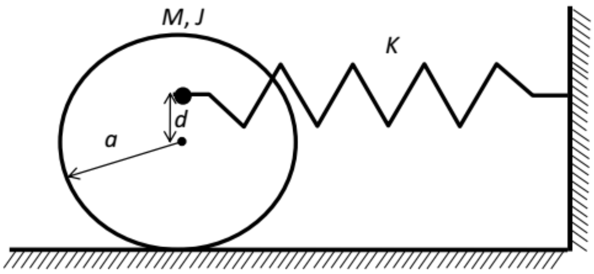
	Arm	Gears		
		2	3	4
All gear locked to Arm & 2 is given x Rotations in C.C.W	0	x	$\frac{-60}{20}x$	$\frac{-60}{100}x$
Arm also given y Rotations in C.C.W	y	y + x	$y-\frac{60}{20}x$	$y-\frac{60}{100}x$

Given: $x+y=0$ ...(1)

$y-\frac{3}{5}x=100$ ...(2)

$$y+\frac{3}{5}y=100 \Rightarrow y=\frac{5\times 100}{8}=62.5 \text{ counter clockwise}$$

37. A solid disc with radius *a* is connected to a spring at a point *d* above the center of the disc. The other end of the spring is fixed to the vertical wall. The disc is free to roll without slipping on the ground. The mass of the disc is *M* and the spring constant is *K*. The polar moment of inertia for the disc about its centre is $J=Ma^2/2$.

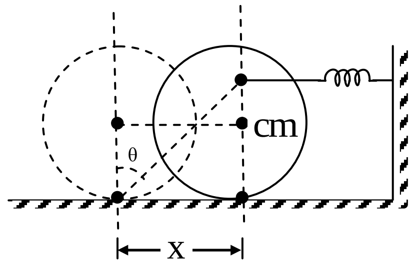


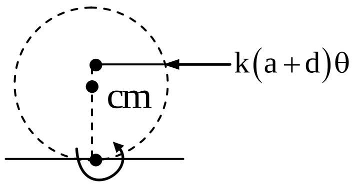
The natural frequency of this system in rad/s is given by

(A) $\sqrt{\frac{2K(a+d)^2}{3Ma^2}}$ (B) $\sqrt{\frac{2K}{3M}}$ (C) $\sqrt{\frac{2K(a+d)^2}{Ma^2}}$ (D) $\sqrt{\frac{K(a+d)^2}{Ma^2}}$

Key: (A)

Exp: Apply D'Alembert Principle:





$$\left[k\left(a+d\right)\theta\right]\left(a+d\right)+\left(I_{cm}+Ma^2\right)\ddot{\theta}=0$$

$$\ddot{\theta}+\frac{k\left(a+d\right)^2}{\left(\frac{Ma^2}{2}+Ma^2\right)}\theta=0$$

$$\omega_n=\sqrt{\frac{2k\left(a+d\right)^2}{3Ma^2}}$$

38. The principal stresses at a point inside a solid object are σ_1 = 100 MPa, σ_2 = 100 MPa and σ_3 = 0 MPa. The yield strength of the material is 200 MPa. The factor of safety calculated using Tresca (maximum shear stress) theory is n_T and the factor of safety calculated using von Mises (maximum distortional energy) theory is n_V. Which one of the following relations is TRUE?

(A) $n_T = \left(\sqrt{3}/2\right) n_v$

(B) $n_T = \left(\sqrt{3}\right) n_v$

(C) $n_T = n_v$

(D) $n_v = \left(\sqrt{3}\right) n_T$

Key: (C)

Exp: $\tau_{max} = {}_{max}\left\{\left|\left(\frac{\sigma_1-\sigma_3}{2}\right)\right|, \left|\left(\frac{\sigma_2-\sigma_3}{2}\right)\right|, \left|\left(\frac{\sigma_3-\sigma_1}{2}\right)\right|\right\} = 50 \text{ Mpa}$

$$\tau_{max} = \frac{\left(S_{yt}/2\right)}{\eta_T} \Rightarrow 50 = \frac{(200/2)}{\eta_T} \Rightarrow \eta_T = 2$$

$$\left[\frac{(\sigma_1-\sigma_2)^2+(\sigma_2-\sigma_3)^2+(\sigma_3-\sigma_1)^2}{2}\right] \le \left(\frac{S_{yt}}{\eta_v}\right)^2$$

$$= \sigma_1^2+\sigma_2^2-\sigma_1\sigma_2 \le \left(S_{yt}/\eta_v\right)^2$$

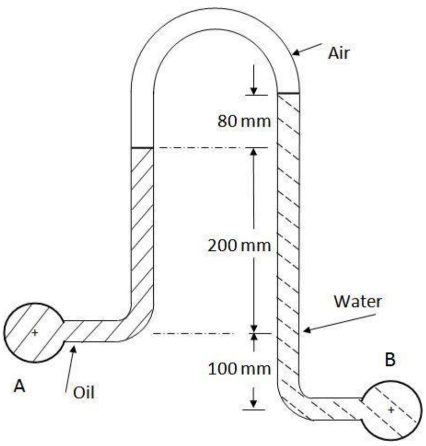
$$\sigma_1 = \sigma_2 = 100 \;\&\; S_{yt} = 200$$

$$(100)^2 = \left(\frac{200}{\eta_v}\right)^2 \Rightarrow \eta_v = 2$$

$$\therefore \eta_T = \eta_v$$

39. An inverted U-tube manometer is used to measure the pressure difference between two pipes A and B, as shown in the figure. Pipe A is carrying oil (specific gravity = 0.8) and pipe B is carrying water. The densities of air and water are 1.16 kg/m^3 and 1000 kg/m^3, respectively. The pressure difference between pipes A and B is __________kPa.

Acceleration due to gravity g = 10 m/s^2.



Key: -2.199

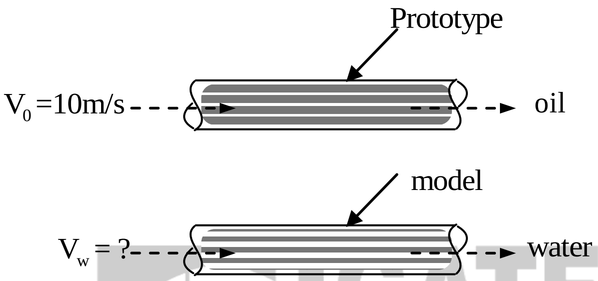
Exp: $P_A - \rho_{oil}gh_1 - \rho_{air}gh_2 = P_B - \rho_{water}g(h_1 + h_2 + h_3)$

$$P_A - P_B = 0.8 \times 10^3 \times 10 \times 0.2 + 1.16 \times 10 \times 0.08 - 10^3 \times 10(0.2 + 0.08 + 0.1)$$
$$= 1600 + 0.928 - 3800$$
$$= -2199.072 \text{ Pa}$$
$$P_A - P_B = -2.199 \text{ kPa}$$

40. Oil (kinematic viscosity, V_{oil} = 1.0 × 10^{-5} m^2/s) flows through a pipe of 0.5 m diameter with a velocity of 10 m/s. Water (kinematic viscosity, v_w= 0.89 × 10−6 m^2/s) is flowing through a model pipe of diameter 20 mm. For satisfying the dynamic similarity, the velocity of water (in m/s) is _____ .

Key: 22.25

Exp:



$\nu_{oil} = 1.0 \times 10^{-5}\ m^2/s$
$d_{oil} = 0.5m$

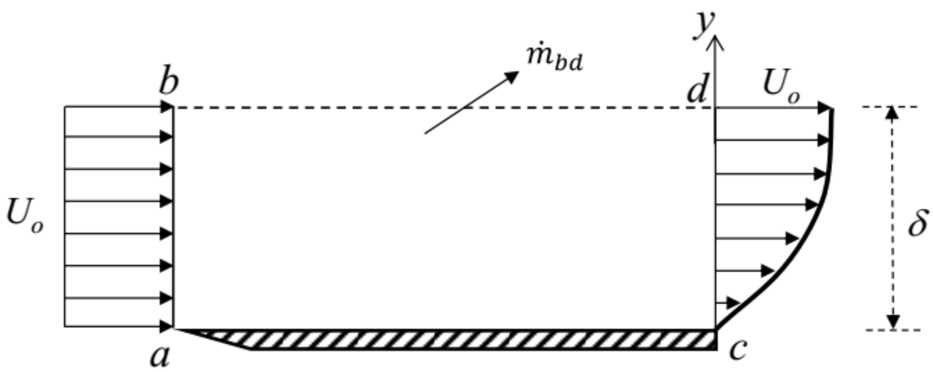
$\nu_w = 0.89 \times 10^{-6} m^2/s$
$d_w = 0.02m$

There is no free surface inside pipe flow, therefore only Reynold numbers are equal in both the cases.

$$(R_e)_{oil} = (R_e)_{water} \Rightarrow \left(\frac{VD}{\nu}\right)_{model} = \left(\frac{VD}{\nu}\right)_{prototype}$$

$$\frac{V_w \times 0.02}{0.89 \times 10^{-6}} = \frac{10 \times 0.5}{1.0 \times 10^{-5}} \Rightarrow V_w = 22.25 m/sec$$

41. A steady laminar boundary layer is formed over a flat plate as shown in the figure. The free stream velocity of the fluid is U_o. The velocity profile at the inlet *a-b* is uniform, while that at a downstream location *c-d* is given by $u = U_0\left[2\left(\frac{y}{\delta}\right) - \left(\frac{y}{\delta}\right)^2\right]$.



The ratio of the mass flow rate, $\dot{m}_{bd}$, leaving through the horizontal section *b-d* to that entering through the vertical section *a-b* is __________.

Key: 0.33

Exp:

This is steady state process, so time derivative will be zero. Choose b-a-c-d-b as Control Volume (CV)

$$\int_{cs} \rho\left(\vec{V}.\hat{n}\right) dA = 0$$

where C.S $\rightarrow$ stands for control surface &

$\hat{n}$ is unit vector perpendicular to Area of flow which is always taken outside of side of cross-sectional Area.

Let fluid is incompressible, ρ= constant

$$\rho\int_b^a \left(\vec{V}.\hat{n}\right) dA + \rho\int_a^\delta \left(\vec{V}.\hat{n}\right) dA + \rho\int_c^d \left(\vec{V}.\hat{n}\right) dA + \rho\int_d^b \left(\vec{V}.\hat{n}\right) dA = 0$$

$$\rho\int_0^\delta -U_0\, b.dy + \rho\int_a^\delta \left(\vec{0}.\hat{n}\right) dA + \rho\int_c^\delta U_0\left[2\left(\frac{y}{\delta}\right)^2 - \left(\frac{y}{\delta}\right)^2\right] b\,dy + \dot{m}_{bd} = 0$$

$$-U_0 b\rho\delta + 0 + \rho V b\left[\delta - \frac{\delta}{3}\right] + \dot{m}_{bd} = 0$$

$$-U_0 b\rho\delta + \frac{2}{3}\rho b V_0 \delta + \dot{m}_{bd} = 0$$

$$\dot{m}_{bd} = \frac{1}{3}\left(\rho U_0 b\delta\right)$$

$$\frac{\dot{m}_{bd}}{\rho U_0 b\delta} = 0.33$$

42. A steel ball of 10 mm diameter at 1000 K is required to be cooled to 350 K by immersing it in a water environment at 300 K. The convective heat transfer coefficient is 1000 W/m^2-K. Thermal conductivity of steel is 40 W/m-K. The time constant for the cooling process τ is 16 s. The time required (in s) to reach the final temperature is _____

Key: 42.22

Exp: Given

d = 10 mm = 0.01 m

$$t_i = 1000K; t = 350K; t_\infty = 300K; \quad k = 40\,\frac{W}{mK}; h = 1000\,\frac{W}{m^2K}; \tau_{th} = 16s$$

$$\frac{t - t_\infty}{t_i - t_\infty} = e^{-\tau/\tau_{th}}$$

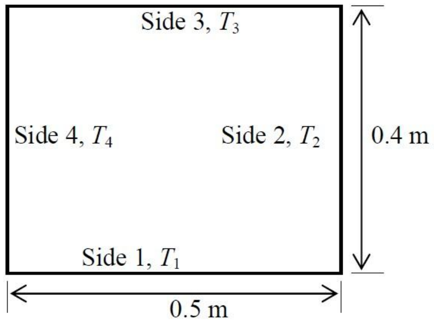
$$\ln\left(\frac{t - t_\infty}{t_i - t_\infty}\right) = -\tau/\tau_{th}$$

$$\ln\left(\frac{350 - 300}{1000 - 300}\right) = -\tau/16$$

$$\tau = 42.22s$$

43. An infinitely long furnace of 0.5 m × 0.4 m cross-section is shown in the figure below. Consider all surfaces of the furnace to be black. The top and bottom walls are maintained at temperature $T_1 = T_3 = 927^oC$ while the side walls are at temperature $T_2 = T_4 = 527\ ^oC$. The view factor, $F_{1\text{-}2}$ is 0.26. The net radiation heat loss or gain on side 1 is_________ W/m.

Stefan-Boltzmann constant = 5.67×10^{-8} W/m^2-K^4



Key: 24530.688

44. A fluid (Prandtl number, $Pr = 1$) at 500 K flows over a flat plate of 1.5 m length, maintained at 300 K. The velocity of the fluid is 10 m/s. Assuming kinematic viscosity, $\nu = 30 \times 10^{-6}$ m^2/s, the thermal boundary layer thickness (in mm) at 0.5 m from the leading edge is ______.

Key: 6.124

Exp: Pr = 1

$$Re_x = \frac{ux}{\nu} = \frac{10 \times 0.5}{30 \times 10^{-6}}$$

$$= 166666.67$$

$$= 1.67 \times 10^5$$

Hydrodynamic boundary layer thickness

$$\delta_{h_x} = \frac{5x}{\sqrt{Re_x}} = \frac{5 \times 0.5}{\sqrt{1.67 \times 10^5}}$$

$$= 6.124 \times 10^{-3}\ \text{m}$$

If Pr = 1

$$\delta_{h_x} = \delta_{T_x} = 6.124 \times 10^{-3}\ \text{m}$$

$$= 6.124\ \text{mm}$$

∴ Thermal boundary layer thickness = 6.124 mm.

45. For water at 25°C, $dp_s / dT_s = 0.189\,\text{kPa/K}$ (p_s is the saturation pressure in kPa and T_s is the saturation temperature in K) and the specific volume of dry saturated vapour is 43.38 m^3/kg. Assume that the specific volume of liquid is negligible in comparison with that of vapour. Using the Clausius- Clapeyron equation, an estimate of the enthalpy of evaporation of water at 25°C (in kJ/kg) is ______.

Key: 2443.24

Exp: $\frac{dP_s}{dT_s}=\frac{h_{fg}}{T_s\left(v_g-v_f\right)}\Rightarrow 0.189=\frac{h_{fg}}{(25+273)(43.38-0)}$

$\Rightarrow h_{fg}=2443.248\,\text{kJ/kg}$

46. An ideal gas undergoes a reversible process in which the pressure varies linearly with volume. The conditions at the start (subscript 1) and at the end (subscript 2) of the process with usual notation are: $p_1=100\,\text{kPa}$, $V_1=0.2\text{m}^3$ and $p_2=200\,\text{kPa}$, $V_2=0.1\text{m}^3$ and the gas constant, R = 0.275 kJ/kg-K. The magnitude of the work required for the process (in kJ) is __________.

Key: 15

Exp: Pressure varies linearly with volume.

P = a + bv

$P_1=a+bv_1$

$\Rightarrow 100=a+b\times 0.2 \qquad -----(1)$

$P_2=a+bv_2$

$\Rightarrow 200=a+b\times 0.1 \qquad -----(2)$

Solving (1) & (2)

$-100=0.1b\Rightarrow b=\frac{100}{0.1}=-1000$

$b=-1000$

Substituting in any of the equations to get ‘a’.

$\Rightarrow 100=a+(-1000\times 0.2)\Rightarrow \qquad a=300$

$\therefore W=\int_1^2 p\,dv=\int_1^2(a+bv)dv$

$=\int_1^2(300-1000v)dv\ =300(v_2-v_1)-1000\left(\frac{v_2^2-v_1^2}{2}\right)$

$=300(0.1-0.2)-1000\left(\frac{(0.1)^2-(0.2)^2}{2}\right)=-30-(-15)\ =-15\text{kJ}$

$\therefore$ Magnitude of work required is 15 kJ.

47. In a steam power plant operating on an ideal Rankine cycle, superheated steam enters the turbine at 3 MPa and 350^{O}C. The condenser pressure is 75 kPa. The thermal efficiency of the cycle is ________ percent.

Given data:

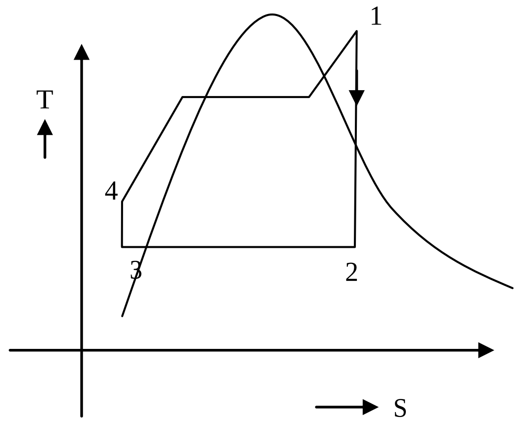
For saturated liquid, at P = 75 kPa, $h_f=384.39\text{kJ/kg}$, $v_f=0.001037\text{m}^3/\text{kg}$, $s_f=1.213\text{kJ/kg}-\text{K}$

At 75 kPa, h_{fg} = 2278.6 kJ/kg, s_{fg} = 6.2434 kJ/kg-K

At P = 3 MPa and T = 350^{O}C (superheated steam), $H=3115.3\text{kJ/kg}$, $s=6.7428\text{kJ/kg}-\text{K}$

Key: 25.99%

Exp:



Given:- $P_1 = P_4 = 3MPa, T_1 = 350^oC = 350 + 273 = 623K$

$h_1 = 3115.3kJ/kg, S_1 = 6.7428kJ/kgK$

$P_2 = P_3 = 75kPa.$

$h_{f_2} = h_{f_3} = 384.39kJ/kg, h_{fg_2} = 2278.6kJ/kg$

$s_{f_2} = s_{f_3} = 1.213kJ/kgK, s_{fg_2} = 6.2434kJ/kgK$

$v_{f_3} = 0.001037m^3/kg$

$S_1 = S_2$

$\Rightarrow S_1 = S_{f_2} + x_2 S_{fg_2}$

$6.7428 = 1.213 + \{x_2 \times 6.2434\}$

$x_2 = 0.886$

$h_2 = h_{f_2} + x_2 h_{fg_2} = 384.39 + \{0.886 \times 2278.6\}$

$= 2403.2296kJ/kg$

$\simeq 2403.23$

Turbine work, $W_T = h_1 - h_2 = 3115.3 - 2403.23 = 712.07kJ/kg$

Pump work, $W_p = v_{f_3}(P_4 - P_3) = 0.001037(3000 - 75)$

$= 3.03kJ/kg$

$h_4 = h_3 + W_p = h_{f_3} + W_p = 384.39 + 3.03$

$= 387.42kJ/kg$

Heat supplied to boiler

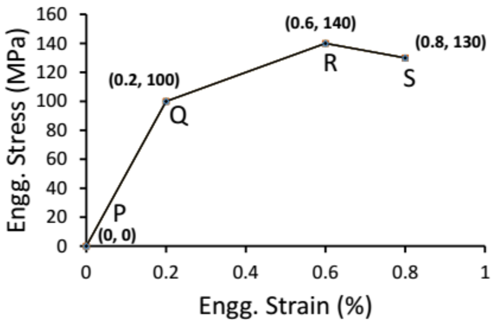
$\therefore h_1 - h_4 = 3115.3 - 387.42$

$= 2727.88kJ/kg$

Net work done $= W_T - W_p = 712.07 - 3.03 = 709.04kJ/kg$

$$\text{Thermal efficiency}(\eta) = \frac{\text{Net work done}}{\text{Heat supplied}} = \frac{709.04}{2727.88} \times 100 = 25.99\%$$

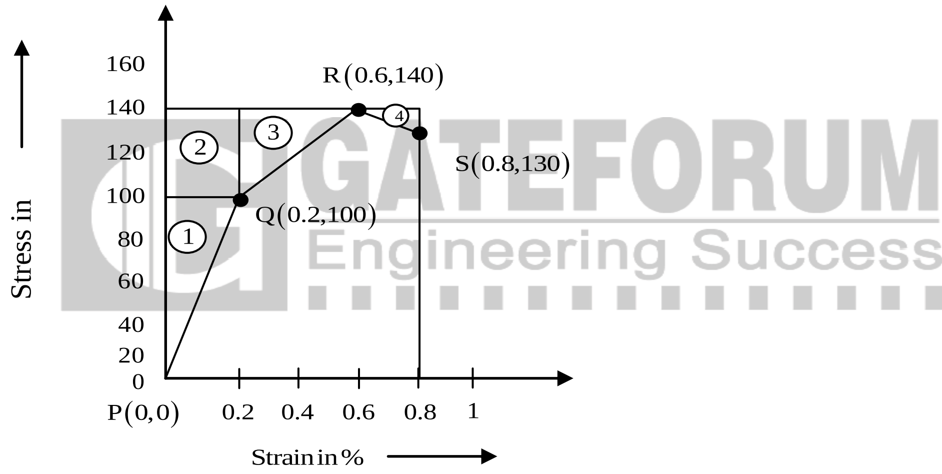
48. A hypothetical engineering stress-strain curve shown in the figure has three straight lines PQ, QR, RS with coordinates P(0,0), Q(0.2,100), R(0.6,140) and S(0.8,130). 'Q' is the yield point, 'R' is the UTS point and 'S' the fracture point.



The toughness of the material (in MJ/m^3) is ________.

Key: 0.85

Exp:



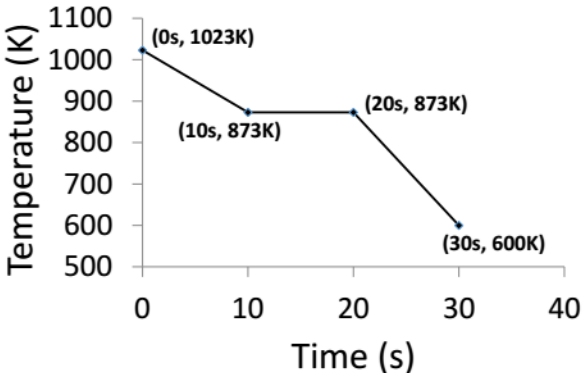
Toughness of material

Total area – [Area of 1 + Area of 2 + Area of 3 + Area of 4]

$$=\left(140\times\frac{0.8}{100}\right)-\left[\left\{\frac{1}{2}\times100\times\frac{0.2}{100}\right\}+\left\{40\times\frac{0.2}{100}\right\}+\left\{\frac{1}{2}\times40\times\frac{0.4}{100}\right\}+\left\{\frac{1}{2}\times10\times\frac{0.2}{100}\right\}\right]$$

$$=1.12-[0.1+0.08+0.08-0.01]=0.85\,\mathrm{MJ/m^3}$$

49. Heat is removed from a molten metal of mass 2 kg at a constant rate of 10 kW till it is completely solidified. The cooling curve is shown in the figure.



Assuming uniform temperature throughout the volume of the metal during solidification, the latent heat of fusion of the metal (in kJ/kg) is __________.

Key: (50)

Exp: Given

$m = 2\text{ kg}; \quad Q = 10\text{ kcal}$

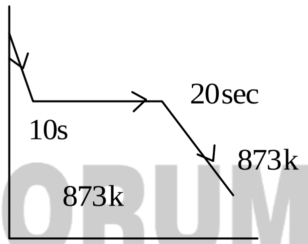
Since heat is removed at constant rate

10kw is removed per second.

So, latest heat = $mL = 10\,kW \times (10\,sec)$

$2L = 100\text{ kJ}$

$L = 50\text{kJ / kg}$



10 sec is time required for phase change

50. The tool life equation for HSS tool is $VT^{0.14}f^{0.7}d^{0.4} =$ Constant. The tool life (T) of 30 min is obtained using the following cutting conditions:

$V = 45$ m/min, $f = 0.35$ mm, $d = 2.0$ mm

If speed (V), feed (f) and depth of cut (d) are increased individually by 25%, the tool life (in min) is

(A) 0.15 (B) 1.06 (C) 22.50 (D) 30.0

Key: (B)

Exp: $VT^{0.14} f^{0.7} d^{0.4} = \text{constant}$

$$V_1 = 45\text{m/min}; \quad f_1 = 0.35\text{mm}; \quad d_1 = 2\text{mm}$$
$$T_1 = 30\,\text{min}; \quad V_2 = 1.25\,V_1;$$
$$f_2 = 1.25 f_1; \quad d_1 = 1.25 d_1;$$
$$T_2 = ?$$

$$\Rightarrow 45 \times T_1^{0.14}\ f_1^{0.7}\ d_1^{0.4} = 1.25 \times 45 \times T_2^{0.14} \times 1.25^{0.7}\ f_1^{0.7} \times 1.25^{0.4} d_1^{0.4}$$
$$\Rightarrow T_1^{0.14} = 1.25 \times 1.25^{0.7} \times 1.25^{0.4} \times T_2^{0.14}$$
$$\Rightarrow T_2 = \frac{(30)^{0.14}}{1.25^{2.1} / 0.14} = 1.055 = 1.06$$

51. A cylindrical job with diameter of 200 mm and height of 100 mm is to be cast using modulus method of riser design. Assume that the bottom surface of cylindrical riser does not contribute as cooling surface. If the diameter of the riser is equal to its height, then the height of the riser (in mm) is

(A) 150 (B) 200 (C) 100 (D) 125

Key: (A)

Exp: $d_c = 200\text{ mm}$ $\quad d_r = h_r$ $\quad C = \text{Casting}$

$h_c = 100\text{ mm}$ $\quad h_r = ?$ $\quad R = \text{Rises}$

$$M_r = 1.2\,M_C$$

$$\left(\frac{V}{S}\right)_r = 1.2\left(\frac{V}{S}\right)_C$$

$$\frac{\frac{\pi}{4}d_r^2 hr}{\pi d_r h_r + \frac{\pi}{4}d_r^2} = 1.2\,\frac{\frac{\pi}{4}d_c^2 h_c}{d_c h_c + \frac{\pi}{4}d_c^2 x^2}$$

$$= \frac{dr^2 h_r}{4d_r h_r + d_r^2} = \frac{1.2 d_c^2 h_c}{4d_c h_c + 2d_c^2}$$

$$= \frac{h_r^3}{4h_r^2 + h_r^2} = \frac{1.2\times(200)^2\times 100}{4\times 200\times 100 + 2\times 200^2}\left[\because d_v = h_r\right]$$

$$= \frac{h_r}{5} = 1.2\times\frac{200\times 10}{4\times 100 + 2\times 200}$$

$$= h_r = 1.2\times 5\times\frac{200\times 100}{4\times 200} = 125\times 1.2 = 150$$

52. A 300 mm thick slab is being cold rolled using roll of 600 mm diameter. If the coefficient of friction is 0.08, the maximum possible reduction (in mm) is ________.

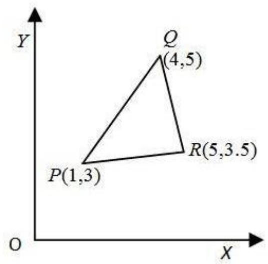
Key: 1.92

Exp: $(\Delta h)_{max} = \mu^2 R$

$$= (0.08)^2 \times 300$$

$$= 1.92\text{ mm}$$

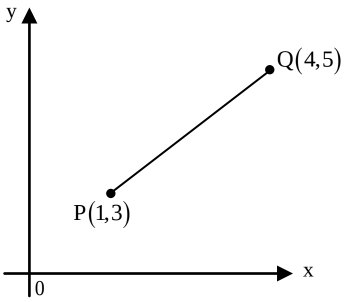
53. The figure below represents a triangle *PQR* with initial coordinates of the vertices as *P*(1,3), *Q*(4,5) and *R*(5,3.5). The triangle is rotated in the *X-Y* plane about the vertex *P* by angle θ in clockwise direction. If sin θ = 0.6 and cos θ = 0.8, the new coordinates of the vertex *Q* are



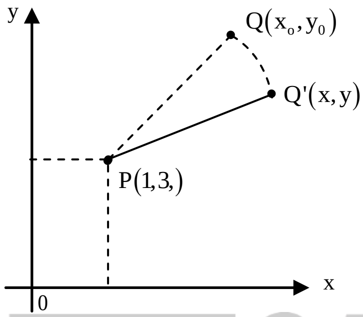
(A) (4.6, 2.8) (B) (3.2, 4.6) (C) (7.9, 5.5) (D) (5.5, 7.9)

Key: (A)

Exp:



Rotate PQ by θ in clockwise direction



Rotation of point Q about point P in anticlockwise is given as

$$x_n - x_p = (x_o - x_p)\cos\theta - (y_o - y_p)\sin\theta \qquad ...(1)$$

$$y_n - y_p = (x_o - x_p)\sin\theta + (y_o - y_p)\cos\theta \qquad ...(2)$$

For clockwise rotation θ will be $(-\theta)$. So the desired equation will be

$$x_n = x_p + (x_o - x_p)\cos\theta + (y_o - y_p)\sin\theta \qquad ...(3)$$

$$= 1 + (4-1)\times 0.8 + (5-3)\times 0.6$$
$$= 1 + 2.4 + 1.2 = 4.6$$

$$y_n = y_p + (y_o - y_p)\sin\theta + (y_o - y_p)\cos\theta \qquad ...(4)$$

$$= 3 - (4-1)\times 0.6 + (5-3)\times 0.8$$
$$= 3 - 1.8 + 1.6$$

$$y_n = 2.8$$

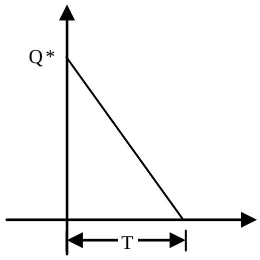
54. The annual demand for an item is 10,000 units. The unit cost is Rs. 100 and inventory carrying charges are 14.4% of the unit cost per annum. The cost of one procurement is Rs. 2000. The time between two consecutive orders to meet the above demand is ______ month(s).

Key: 2

Exp: D= 10,000, Cu = Rs 100, C_h= 0.144×Cu, C_o=Rs 2,000.

$$Q^* = \sqrt{\frac{2DC_0}{C_h}} = \sqrt{\frac{2\times 10,000\times 2000}{0.144\times 100}} = 1666.67\text{ units}$$

$$\text{We know } T = \frac{Q^*}{D} = \frac{1666.67}{10,000} = 0.1667\text{ years } = 2\text{ months}$$



55. Maximize $Z=15X_1 + 20X_2$

subject to

$12X_1 + 4X_2 \geq 36$

$12X_1 - 6X_2 \leq 24$

$X_1, X_2 \geq 0$

The above linear programming problem has

(A) infeasible solution
(B) unbounded solution
(C) alternative optimum solutions
(D) degenerate solution

Key: (B)

Exp: Max $Z = 15x_1 + 20x_2$

Subject to

$12x_1 + 4x_2 \geq 36$

$12x_1 - 6x_2 \leq 24$

$x_1, x_2 \geq 0$

Since, there is no limitation of boundary for the feasible region therefore, the LPP has unbounded solution.