Q. No. 1 – 5 Carry One Mark Each

1. Choose the most appropriate phrase from the options given below to complete the following sentence.

The aircraft_______ take off as soon as its flight plan was filed.

(A) is allowed to (B) will be allowed to

(C) was allowed to (D) has been allowed to

Answer: (C)

2. Read the statements:

All women are entrepreneurs.

Some women are doctors

Which of the following conclusions can be logically inferred from the above statements?

(A) All women are doctors (B) All doctors are entrepreneurs

(C) All entrepreneurs are women (D) Some entrepreneurs are doctors

Answer: (D)

3. Choose the most appropriate word from the options given below to complete the following sentence.

Many ancient cultures attributed disease to supernatural causes. However, modern science has largely helped _________ such notions.

(A) impel (B) dispel (C) propel (D) repel

Answer: (B)

4. The statistics of runs scored in a series by four batsmen are provided in the following table, Who is the most consistent batsman of these four?

Batsman	Average	Standard deviation
K	31.2	5.21
L	46.0	6.35
M	54.4	6.22
N	17.9	5.90

(A) K (B) L (C) M (D) N

Answer: (A)

Exp: If the standard deviation is less, there will be less deviation or batsman is more consistent

5. What is the next number in the series?

12 35 81 173 357 ____

Answer: 725

Exp:

12 35 81 173 357 ________

Difference: $\boxed{23}$ 46 92 184 368

$$\Rightarrow \begin{array}{r} 357 \\ \underline{368} \\ 725 \end{array}$$

Q. No. 6 – 10 Carry One Mark Each

6. Find the odd one from the following group:

W,E,K,O I,Q,W,A F,N,T,X N,V,B,D

(A) W,E,K,O (B) I,Q,W,A (B) F,N,T,X (D) N,V,B,D

Answer: (D)

Exp:

$\underbrace{W \quad E}_{8}\ \underbrace{E \quad K}_{6}\ \underbrace{K \quad O}_{4}$ $\underbrace{I \quad Q}_{8}\ \underbrace{Q \quad W}_{6}\ \underbrace{W \quad A}_{4}$ $\underbrace{F \quad N}_{8}\ \underbrace{N \quad T}_{6}\ \underbrace{T \quad X}_{4}$ $\underbrace{N \quad V}_{8}\ \underbrace{V \quad B}_{6}\ \underbrace{B \quad D}_{2}$

Difference of position: D

7. For submitting tax returns, all resident males with annual income below Rs 10 lakh should fill up Form P and all resident females with income below Rs 8 lakh should fill up Form All people with incomes above Rs 10 lakh should fill up Form R, except non residents with income above Rs 15 lakhs, who should fill up Form S. All others should fill Form T. An example of a person who should fill Form T is

(A) a resident male with annual income Rs 9 lakh

(B) a resident female with annual income Rs 9 lakh

(C) a non-resident male with annual income Rs 16 lakh

(D) a non-resident female with annual income Rs 16 lakh

Answer: (B)

Exp: Resident female in between 8 to 10 lakhs haven't been mentioned.

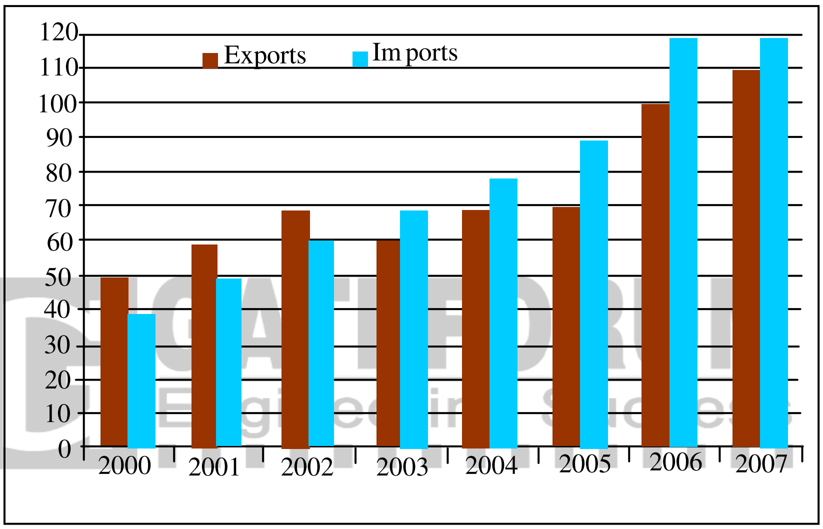
8. A train that is 280 metres long, travelling at a uniform speed, crosses a platform in 60 seconds and passes a man standing on the platform in 20 seconds. What is the length of the platform in metres?

Answer: 560

Exp: For a train to cross a person, it takes 20 seconds for its 280m.

So, for second 60 seconds. Total distance travelled should be 840. Including 280 train length so length of plates =840-280=560

9. The exports and imports (in crores of Rs.) of a country from 2000 to 2007 are given in the following bar chart. If the trade deficit is defined as excess of imports over exports, in which year is the trade deficit 1/5th of the exports?



(A) 2005 (B) 2004 (C) 2007 (D) 2006

Answer: (D)

Exp: $2004, \dfrac{\text{imports} - \text{exports}}{\text{exports}} = \dfrac{10}{70} = \dfrac{1}{7}$

$$2005, \frac{26}{76} = \frac{2}{7}$$

$$2006, \frac{20}{100} = \frac{1}{5}$$

$$2007, \frac{10}{100} = \frac{1}{11}$$

10. You are given three coins: one has heads on both faces, the second has tails on both faces, and the third has a head on one face and a tail on the other. You choose a coin at random and toss it, and it comes up heads. The probability that the other face is tails is

(A) 1/4 (B) 1/3 (C) 1/2 (D) 2/3

Answer: (B)

Q. No. 1 – 25 Carry One Mark Each

1. Given that the determinant of the matrix $\begin{bmatrix} 1 & 3 & 0 \\ 2 & 6 & 4 \\ -1 & 0 & 2 \end{bmatrix}$ is -12, the determinant of the matrix $\begin{bmatrix} 2 & 6 & 0 \\ 4 & 12 & 8 \\ -2 & 0 & 4 \end{bmatrix}$ is

(A) -96 (B) -24 (C) 24 (D) 96

Answer: (A)

Exp: $\begin{vmatrix} 2 & 6 & 0 \\ 4 & 12 & 8 \\ -2 & 0 & 4 \end{vmatrix} = (2)^3 \begin{vmatrix} 1 & 3 & 0 \\ 2 & 6 & 2 \\ -1 & 0 & 2 \end{vmatrix} = 8\times(-12) = -96$

2. $\underset{x\to 0}{\text{Lt}} \dfrac{x-\sin x}{1-\cos x}$ is

(A) 0 (B) 1 (C) 3 (D) not defined

Answer: (A)

Exp: $\lim\limits_{x\to 0} \dfrac{x-\sin x}{1-\cos x} = \left(\dfrac{0}{0}\right)$

Applying L. Hospital Rule, $\lim\limits_{x\to 0} \dfrac{1-\cos x}{\sin x} = \left(\dfrac{0}{0}\right)$

Once again, L. Hospital rule $\lim\limits_{x\to 0} \dfrac{\sin x}{\cos x} = \left(\dfrac{0}{1}\right) = 0$

3. The argument of the complex number $\dfrac{1+i}{1-i}$, where $i=\sqrt{-1}$, is

(A) $-\pi$ (B) $-\dfrac{\pi}{2}$ (C) $\dfrac{\pi}{2}$ (D) π

Answer: (C)

Exp: Given $z=\dfrac{1+i}{1-i} \Rightarrow z=\dfrac{(1+i)(1+i)}{(1-i)(1+i)}$

$= \dfrac{(1+i)^2}{1^2-i^2} = \dfrac{1+2i+i^2}{1+1} = \dfrac{1+2i-1}{2} = i$

$\text{Arg}(z) = \text{Arg}(i)$

$= \tan^{-1}\left(\dfrac{y}{x}\right) = \tan^{-1}\infty = \dfrac{\pi}{2}$

4. The matrix form of the linear system $\frac{dx}{dt} = 3x - 5y$ and $\frac{dy}{dt} = 4x + 8y$ is

(A) $\frac{d}{dt}\begin{Bmatrix} x \\ y \end{Bmatrix} = \begin{bmatrix} 3 & -5 \\ 4 & 8 \end{bmatrix}\begin{Bmatrix} x \\ y \end{Bmatrix}$ (B) $\frac{d}{dt}\begin{Bmatrix} x \\ y \end{Bmatrix} = \begin{bmatrix} 3 & 8 \\ 4 & -5 \end{bmatrix}\begin{Bmatrix} x \\ y \end{Bmatrix}$

(C) $\frac{d}{dt}\begin{Bmatrix} x \\ y \end{Bmatrix} = \begin{bmatrix} 4 & -5 \\ 3 & 8 \end{bmatrix}\begin{Bmatrix} x \\ y \end{Bmatrix}$ (D) $\frac{d}{dt}\begin{Bmatrix} x \\ y \end{Bmatrix} = \begin{bmatrix} 4 & 8 \\ 3 & -5 \end{bmatrix}\begin{Bmatrix} x \\ y \end{Bmatrix}$

Answer: (A)

Exp: Given that $\frac{dx}{dt} = 3x - 5y$

$\frac{dy}{dt} = 4x + 8y$

Matrix term $\frac{d}{dt}\begin{Bmatrix} x \\ y \end{Bmatrix} = \begin{bmatrix} 3 & -5 \\ 4 & 8 \end{bmatrix}\begin{bmatrix} x \\ y \end{bmatrix}$

5. Which one of the following describes the relationship among the three vectors, $\hat{i} + \hat{j} + \hat{k}$, $2\hat{i} + 3\hat{j} + \hat{k}$ and $5\hat{i} + 6\hat{j} + 4\hat{k}$?

(A) The vectors are mutually perpendicular

(B) The vectors are linearly dependent

(C) The vectors are linearly independent

(D) The vectors are unit vectors

Answer: (B)

Exp: Given vectors are $i+j+k$, $2i+3j+k$ and $5i+6j+k$

$$\begin{vmatrix} 1 & 1 & 1 \\ 2 & 3 & 1 \\ 5 & 6 & 1 \end{vmatrix} = 0$$

$\therefore$ Vectors are linearly dependent.

6. A circular rod of length 'L' and area of cross-section 'A' has a modulus of elasticity '*E*' and coefficient of thermal expansion 'α'. One end of the rod is fixed and other end is free. If the temperature of the rod is increased by ΔT, then

(A) Stress developed in the rod is $E\,\alpha\,\Delta T$ and strain developed in the rod is $\alpha\,\Delta T$

(B) Both stress and strain developed in the rod are zero

(C) Stress developed in the rod is zero and strain developed in the rod is $\alpha\,\Delta T$

(D) Stress developed in the rod is $E\,\alpha\,\Delta T$ and strain developed in the rod is zero

Answer: (C)

Exp: Since one end of the rod is fixed and other is free to expand. Hence the Temperature stresses $= 0$ & $\in = \frac{\delta l}{l} = \frac{\alpha \Delta T l}{l} = \alpha \Delta T$

7. A metallic rod of 500mm length and 50mm diameter, when subjected to a tensile force of 100KN at the ends, experiences an increase in its length by 0.5 mm and a reduction in its diameter by 0.015mm. The Poisson's ratio of the rod material is _________

Answer: 0.29 to 0.31

Exp: l = 500 mm, d = 50 mm, p = 100 KN

$\delta l = 0.5$ mm, $\delta l = 0.015$

$$\text{Poisson's Ratio}\left(\frac{1}{m}\right)=\frac{\text{Lateral strain}}{\text{Longitudinal strail}}$$

$$=\frac{\delta d/d}{\delta l/1}=\frac{0.015/50}{0.5/500}=0.3.$$

8. Critical damping is the

(A) Largest amount of damping for which no oscillation occurs in free vibration

(B) Smallest amount of damping for which no oscillation occurs in free vibration

(C) Largest amount of damping for which the motion is simple harmonic in free vibration

(D) Smallest amount of damping for which the motion is simple harmonic in free vibration

Answer: (B)

9. A circular object of radius 'r' rolls without slipping on a horizontal level floor with the center having velocity V. The velocity at the point of contact between the object and the floor is

(A) zero
(B) V in the direction of motion
(C) V opposite to the direction of motion
(D) V vertically upward from the floor

Answer: (A)

Exp: Velocity at point of contact = $R\omega$

(R = Radius of point from Instantaneous centre)

$\because$ The instantaneous centre is at intersection of object and floor, hence radius R = 0

$\therefore$ Velocity at point is zero.

10. For the given statements:

I. Mating spur gear teeth is an example of higher pair

II. A revolute joint is an example of lower pair

Indicate the correct answer.

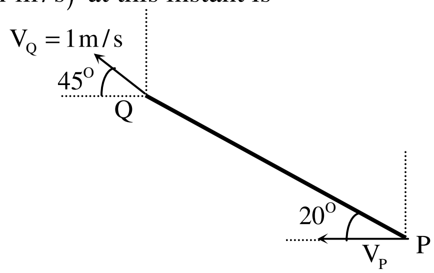
(A) Both I and II are false
(B) I is true and II is false
(C) I is false and II is true
(D) Both I and II are true

Answer: (D)

Exp: Since higher pair has a line or point contact and lower pair has a surface of Area contact. Hence both are true.

i..e,spur gear has line contact (Higher pair) and Revolute joint has surface contact (lower pair).

11. A rigid link PQ is 2 m long and oriented at 20^{O} to the horizontal as shown in the figure. The magnitude and direction of velocity V_Q, and the direction of velocity V_P are given. The magnitude of V_P (in m/s) at this instant is



(A) 2.14 (B) 1.89 (C) 1.21 (D) 0.96

Answer: (D)

Exp: By Instantaneous center method; Say ω = angular velocity of rod

$v_q = r_q.\omega$ ___ (1)

$v_p = r_p.\omega$ ___ (2)

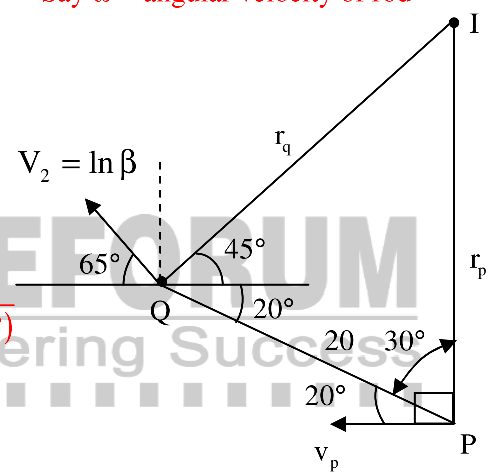
$(1) \div (2)$

$\frac{v_q}{v_p} = \frac{r_q}{r_p}; \; v_p = \frac{r_p}{r_q}.v_q$

Now by sine law, $\frac{r_p}{\sin(45+20)} = \frac{r_q}{\sin(70^\circ)}$

$\frac{r_p}{r_q} = \frac{\sin(65^\circ)}{\sin(70^\circ)}$

so $v_p = \frac{\sin(65)}{\sin(70)} v_q = 0.96.$



12. Biot number signifies the ratio of

(A) Convective resistance in the fluid to conductive resistance in the sold

(B) Conductive resistance in the solid to convective resistance in the fluid

(C) Inertia force to viscous force in the fluid

(D) Buoyancy force to viscous force in the fluid

Answer: (B)

Exp: Biot-number:

Biot number provides a way to compare the conduction resistance within a solid body to the convection resistance external to that body (offered by the surrounding fluid) for heat transfer:

$Bi = \frac{hs}{k}; \; s = \frac{\text{Volume of the body}}{\text{Surface area}}$

Where 's' is a characteristic dimension of the solid

'h' is convective heat transfer coefficient

'k' is thermal conductivity of the body.

13. The maximum theoretical work obtainable, when a system interacts to equilibrium with a reference environment, is called

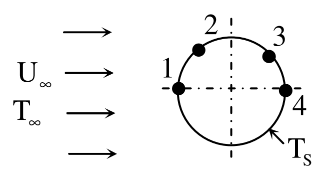
(A) Entropy (B) Enthalpy (C) Exergy (D) Rothalpy

Answer: (C)

Exp: Exergy (or) Available Energy:

The maximum portion of energy which could be converted into useful work by ideal processes which reduce the system to dead state(a state in equilibrium with the earth and its atmosphere).

14. Consider a two-dimensional laminar flow over a long cylinder as shown in the figure below.



The free stream velocity is U_∞ and the free stream temperature T_∞ is lower than the cylinder surface temperature T_S. The local heat transfer coefficient is minimum at point

(A) 1 (B) 2 (C) 3 (D) 4

Answer: (B)

Exp: For laminar flow, the heat transfer coefficient is minimum where the boundary layer thickness is maximum and vice versa. For turbulent-region boundary layer thickness is maximum at 3 but for laminar boundary layer thickness is maximum at 2 so minimum heat transfer coefficient.

15. For a completely submerged body with centre of gravity 'G' and centre of buoyancy 'B', the condition of stability will be

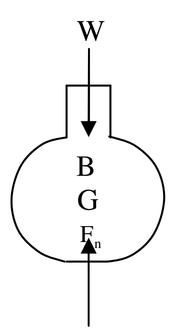
(A) G is located below B (B) G is located above B

(C) G and B are coincident (D) independent of the locations of G and B

Answer: (A)

Exp: A body in a liquid is said to be stable, when given small displacement, it returns to its original position.

Stability of completely submerged Bodies



The center of gravity 'G' is below t he center of Buoyancy 'B'.

16. In a power plant, water (density = 1000 kg/m^3) is pumped from 80 KPa to 3 MPa. The pump has an isentropic efficiency of 0.85. Assuming that the temperature of the water remains the same, the specific work (in kJ/kg) supplied to the pump is

(A) 0.34 (B) 2.48 (C) 2.92 (D) 3.43

Answer: (D)

Exp: $\text{Specific volume} = \dfrac{\text{volume of fluid}}{\text{Mass of fluid}} = \dfrac{1}{\rho} = \dfrac{1}{1000} = 10^{-3}\ \text{m}^3/\text{kg}$

$$\eta = \frac{\text{Isentropic compressor work}}{\text{Actual compressor work}}$$

$$\text{Actual compressor work} = \frac{V(\Delta P)}{\eta}$$

$$= \frac{10^{-3} \times (3000 - 80)\,\text{KPa}}{0.85}$$

$$= \frac{2.92}{0.85} = 3.43\ \text{kJ/kg}.$$

17. Which one of the following is a CFC refrigerant?

(A) R744 (B) R290 (C) R502 (D) R718

Answer: (C)

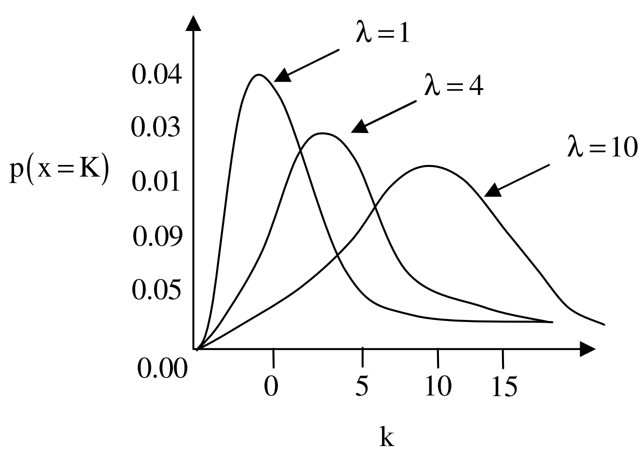
Exp: Among all refrigerants R502 is the only CFC refrigerant.

18. The jobs arrive at a facility, for service, in a random manner. The probability distribution of number of arrivals of jobs in a fixed time interval is

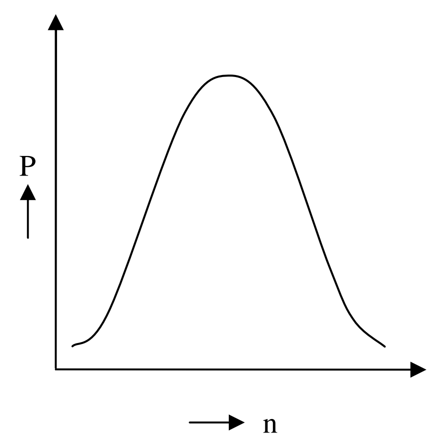
(A) Normal (B) Poisson (C) Erlang (D) Beta

Answer: (B)

Exp:



Poission distribution



Since arrival rates depends upon the time factor, so accordingly graph can be chosen from Poisson distribution, but normal distribution expresses same result throughout.

19. In exponential smoothening method, which one of the following is true?

(A) $0 \le \alpha \le 1$ and high value of α is used for stable demand

(B) $0 \le \alpha \le 1$ and high value of α is used for unstable demand

(C) $\alpha \ge 1$ and high value of α is used for stable demand

(D) $\alpha \le 0$ and high value of α is used for unstable demand

Answer: (B)

Exp: $0 \le \alpha \le 2$

high value of ‘α’ means more weightage for immediate forecast.

Less value of ‘α’ means relatively less weightage for immediate forecast, or almost equal weightage for all previous forecast.

Hence high value of forecast is only chosen when nature of demand is not reliable rather unstable.

20. For machining a rectangular island represented by coordinates P(0,0), Q(100,0), R(100,50) and (0,50) on a casting using CNC milling machine, an end mill with a diameter of 16 mm is used.

The trajectory of the cutter centre to machine the island PQRS is

(A) (−8, −8), (108, −8), (108,58), (−8,58) , (−8, −8)

(B) (8,8), (94,8), (94,44), (8,44), (8,8)

(C) (−8,8), (94,0), (94,44), (8,44), (−8,8)

(D) (0,0), (100,0), (100,50), (50,0), (0,0)

Answer: (A)

Exp: End mill centre ≡ (0,0)

Since Radius of end mill is 8 mm

∴ call point ‘p’ ≡ -8, -8

Call point ‘Q’ ≡ (100+8, -8+0) ≡ (108,-8)

→x direction

Call point ‘R’ ≡ (108+0, 50+8) ≡ (108,58)

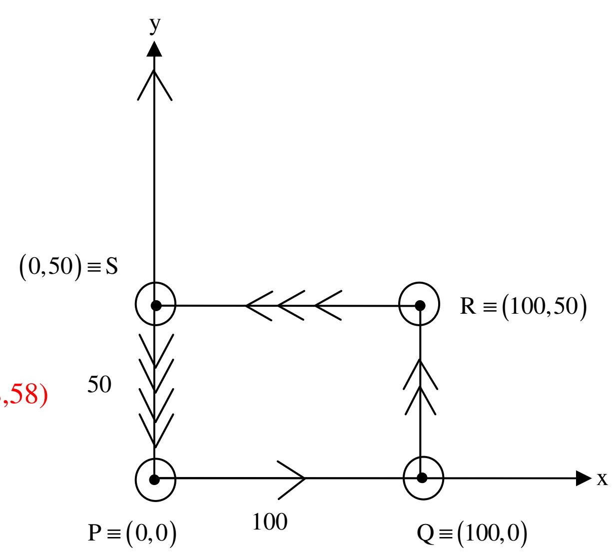
→y direction

Call point ‘S’ ≡ (108-100 -2×8,58-0) ≡ (-8,58)

→-x direction

Call point ‘P’ ≡ (-8-0, 50-50-8) ≡ (-8,-8)

→-y direction



21. Which one of the following instruments is widely used to check and calibrate geometric features of machine tools during their assembly?

(A) Ultrasonic probe

(B) Coordinate Measuring Machine (CMM)

(C) Laser interferometer

(D) Vernier callipers

Answer: (C)

Exp: Geometric accuracy of the machine tools are generally checked by Laser interferometer, as it is very cheap and easy to handle.

22. The major difficulty during welding of aluminium is due to its

(A) High tendency of oxidation (B) high thermal conductivity

(C) Low melting point (D) low density

Answer: (A)

23. The main cutting force acting on a tool during the turning (orthogonal cutting) operation of a metal is 400 N. The turning was performed using 2 mm depth of cut and 0.1 mm/rev feed rate. The specific cutting pressure (in N/mm²) is

(A) 1000 (B) 2000 (C) 3000 (D) 4000

Answer: (B)

Exp:
$$\text{specific cutting energy} = \frac{F_C}{b \times t_1} = \frac{400}{2 \times 0.1} = 2000\ N/mm^2.$$

24. The process of reheating the martensitic steel to reduce its brittleness without any significant loss in its hardness is

(A) Normalising (B) annealing (C) quenching (D) tempering

Answer: (A)

25. In solid-state welding, the contamination layers between the surfaces to be welded are removed by

(A) Alcohol (B) plastic deformation

(C) water jet (D) sand blasting

Answer: (B)

Q. No. 26 – 55 Carry Two Marks Each

26. The integral $\oint_c (ydx - xdy)$ is evaluated along the circle $x^2 + y^2 = \frac{1}{4}$ traversed in counter clockwise direction. The integral is equal to

(A) 0 (B) $-\frac{\pi}{4}$ (C) $-\frac{\pi}{2}$ (D) $\frac{\pi}{4}$

Answer: (C)

Exp: Given integral $\oint_c (ydx - xdy)$ where C is $x^2 + y^2 = \frac{1}{4}$

Applying Green's theorem

$$\oint_c Mdx - Ndy = \iint_R \left(\frac{\partial N}{\partial x} - \frac{\partial M}{\partial y}\right) dxdy$$

where R is region included in c

$$\oint_c ydx - xdy = \iint_R (-1-1)\, dxdy$$

$$= -2 \iint_R dxdy = -2 \times \text{Region } R = -2 \times \text{area of circle with radius } \frac{1}{2}$$

$$= -2 \times \pi \left(\frac{1}{2}\right)^2 = \frac{-\pi}{2}$$

27. If $y = f(x)$ is solution of $\frac{d^2y}{dx^2} = 0$ with the boundary conditions y = 5 at x = 0, and $\frac{dy}{dx} = 2$ at $x = 10, f(15) =$ ________

Answer: 34 to 36

Exp: Given $\frac{d^2y}{dx^2} = 0$, $y = 5$ at $x = 0$, $\frac{dy}{dx} = 2$ at $x = 10$

$\Rightarrow$ Auxiliary equation is $m^2 = 0$

$\Rightarrow m = 0, 0$

$y_c = (c_1 + c_2 x)e^x = c_1 + c_2 x$

$y_p = 0$

General solution $y = y_c + y_p \quad \Rightarrow y = c_1 + c_2 x$

$y = 5$ at $x = 0 \quad \Rightarrow c_1 = 5$

$\frac{dy}{dx} = 2$ at $x = 10 \Rightarrow 2 = c_2$

$y = 5 + 2x$

$y(15) = 5 + 30 = 35$

28. In the following table, x is a discrete random variable and p(x) is the probability density. The standard deviation of x is

X	1	2	3
p(x)	0.3	0.6	0.1

(A) 0.18 (B) 0.36 (C) 0.54 (D) 0.6

Answer: (D)

Exp: Given

x	1	2	3
$p(x)$	0.3	0.6	0.1

$$\text{mean}(\mu) = \exp(x) = 1\times 0.3 + 2\times 0.6 + 3\times 0.1$$
$$= 0.3 + 1.2 + 0.3$$
$$= 1.8$$
$$E(x^2) = \Sigma x^2 P(x)$$
$$= 1\times 0.3 + 4\times 0.6 + 9\times 0.1$$
$$= 0.3 + 2.4 + 0.9$$
$$= 3.6$$
$$\text{Variance } v(x) = E(x^2) - \mu^2 = 3.6 - (1.8)^2$$
$$\text{S.D } (\sigma) = +\sqrt{v(x)} = +\sqrt{3.6-(1.8)^2} = \sqrt{0.36} = 0.6$$

29. Using the trapezoidal role, and dividing the interval of integration into three equal subintervals, the definite integral $\int_{-1}^{+1} |x| dx$ is ______

Answer: 1.10 to 1.12

Exp: $\int_{-1}^{+1} |x|\, dx$

Let $y = |x|$

$n =$ no. of subintervals $= 3$

$$h = \frac{x_n - n_o}{n} = \frac{1-(-1)}{3} = \frac{2}{3}$$

Values of x are, $-1,\ -1+\frac{2}{3},\ -1+2\left(\frac{2}{3}\right),\ -1+3\left(\frac{2}{3}\right)$

x	-1	$-\frac{1}{3}$	$\frac{1}{3}$	1
$y = \lvert x \rvert$	1	$\frac{1}{3}$	$\frac{1}{3}$	1

$$\text{trapezodial rule} = \int_{x_0}^{x^n} f(x)dx = \frac{h}{2}\left[(y_o + y_n) + 2(y_1 + \dots\dots + y_{n-1})\right]$$
$$= \int_{-1}^{1} |x| dx = \frac{1}{3}\left[(1+1) + 2\left(\frac{1}{3}+\frac{1}{3}\right)\right]$$
$$= \frac{1}{3}\left[2 + \frac{4}{3}\right] = \frac{1}{3}\times\frac{10}{3} = \frac{10}{9} = 1.1111$$

30. The state of stress at a point is given by $\sigma_x = -6$ MPa, $\sigma_y = 4$ MPa, and $\tau_{xy} = -8$ MPa. The maximum tensile stress (in MPa) at the point is ______________

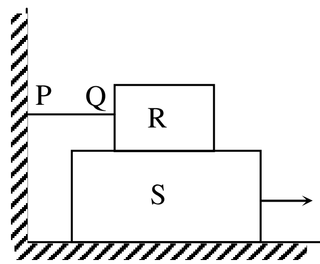
Answer: 8.4 to 8.5

Exp: $$\sigma_1 = \frac{\sigma_x + \sigma_y}{2} + \sqrt{\left(\frac{\sigma_x - \sigma_y}{2}\right)^2 + \left(\tau_{xy}\right)^2}$$

$$= \frac{-6+4}{2} + \sqrt{\left(\frac{-6-4}{2}\right)^2 + (-8)^2}$$

$$= 8.43.$$

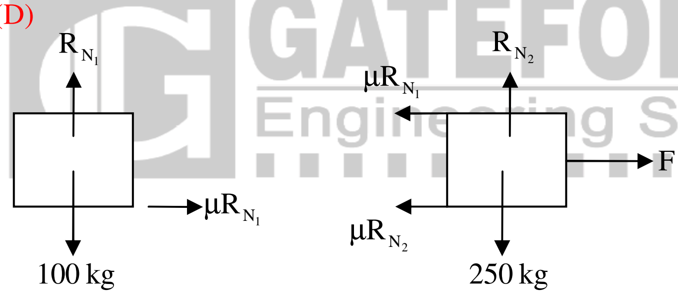
31. A block R of mass 100 kg is placed on a block S of mass 150kg as shown in the figure. Block R is tied to the wall by a mass less and inextensible string PQ. If the coefficient of static friction for all surfaces is 0.4 the minimum force F (in KN) needed to move the block S is



(A) 0.69 (B) 0.88 (C) 0.98 (D) 1.37

Answer: (D)

Exp:



$$F = 0.4 \times 100 \times 9.81 + 0.4 \times 250 \times 9.81$$
$$= 1.37 \text{ kN}.$$

32. A pair of spur gears with module 5 mm and a centre distance of 450 mm is used for a speed reduction of 5:1. The number of teeth on pinion is_______

Answer: 29 to 31

Exp: Given speed Ratio = 5:1

$$\frac{5}{1} = \frac{T_2}{T_1} = \frac{d_2}{d_1} \Rightarrow d_2 = 5d_1$$

$$\text{centre distance} = \frac{d_1 + d_2}{2} = 450$$

$$\Rightarrow d_1 + d_2 = 900 \Rightarrow 5d_1 + d_1 = 900$$

$$\Rightarrow d_1 = 150$$

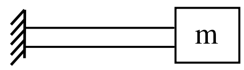
$$m = \frac{d_1}{T_1} \Rightarrow T_1 = \frac{150}{5} = 30.$$

33. Consider a cantilever beam, having negligible mass and uniform flexural rigidity, with length 0.01 m. The frequency of vibration of the beam, with a 0.5 kg mass attached at the free tip, is 100 Hz. The flexural rigidity (in N.m²) of the beam is _______

Answer: 0.064 to 0.067

Exp: $S = \dfrac{FL^3}{3EI}$

$k = \dfrac{F}{S} = \dfrac{3EI}{l^3}$



$k = \dfrac{3Ei}{0.01^3}$

$k = 3{,}000{,}000\ EI$

$\omega_n = \sqrt{\dfrac{k}{m}} = \sqrt{\dfrac{3000{,}000\ EI}{0.5}}$

$\omega_n = 2449.48\sqrt{EI}$

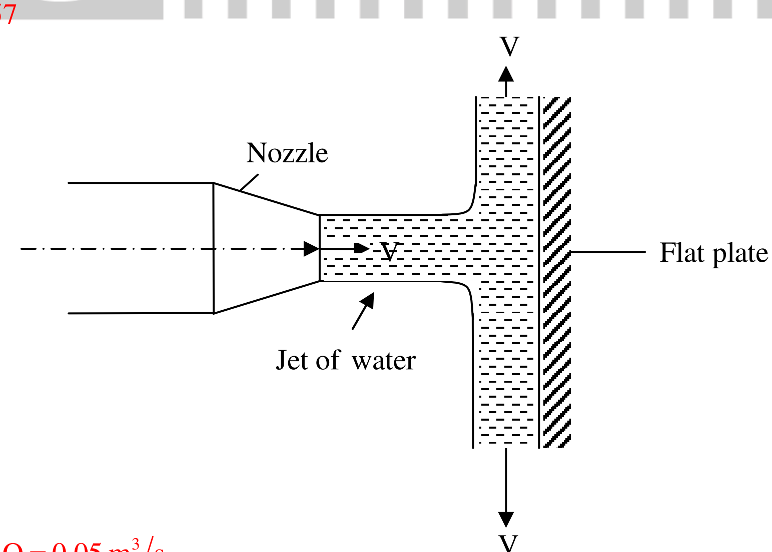
$f_n = \dfrac{\omega_n}{2\pi} \Rightarrow 100 = \dfrac{2449.48\sqrt{EI}}{2\pi}$

$EI = 0.065\ N.m^2.$

34. An ideal water jet with volume flow rate of $0.05\ m^3/s$ strikes a flat plate placed normal to its path and exerts a force of 1000 N. Considering the density of water as $1000\ Kg/m^3$, the diameter (in mm) of the water jet is ______

Answer: 56 to 57

Exp:



Given : $Q = 0.05\ m^3/s$

$F_x = 1000\ N$

$\rho = 1000\ kg/m^3$

$D = ?$

F_x = Rate of change of momentum in the direction of force

$$= \frac{\text{mass}}{\text{time}} \times [\text{initial velocity} - \text{Final velocity}]$$

$$\frac{\text{mass}}{\text{sec}} = \rho a v, \text{ velocity of jet after striking is equal to zero}$$

$$\therefore \rho a V(V-0) = F_x \qquad \left[\because Q = aV \Rightarrow v = \frac{Q}{a}\right]$$

$$1000 = 1000 \times a \times \frac{Q^2}{a^2}$$

$$Q^2 = a; \quad a = (0.05)^2$$

$$\frac{\pi}{4} d^2 = 2.5 \times 10^{-3}$$

$$d = 0.05641\text{ m} = 56.41\text{ mm.}$$

35. A block weighing 200 N is in contact with a level plane whose coefficients of static and kinetic friction are 0.4 and 0.2, respectively. The block is acted upon by a horizontal force (in Newton) *P*=10*t*, where *t* denotes the time in seconds. The velocity (in m/s) of the block attained after 10 seconds is ________

Answer: 4.8 to 5.0

Exp: By 2nd law of Newton in x direction

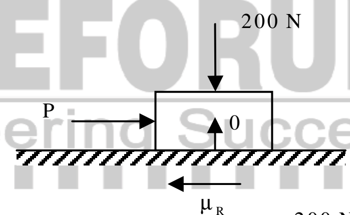
$$P - \mu_k R = ma$$

$$\Rightarrow P - \mu_k R = m\frac{dv}{dt}$$

$$\Rightarrow v_2 - v_1 = \int_1^2 dv = \frac{1}{m}\int_{t_1}^{t_2} (P - \mu_k R)\,dt$$

$$= \frac{1}{\left(\frac{200}{9.81}\right)} \int_0^{10} (10t - 0.2 \times 200)\,dt$$

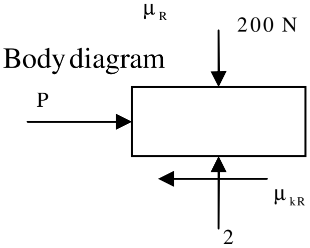
$$v_2 - 0 = 4.90\text{ m/s.}$$



$Zf_y = 0$

$R = 200$ N

Free Body diagram



36. A slider crank mechanism has slider of mass 10 kg, stroke of 0.2 m and rotates with a uniform angular velocity of 10 rad/s. The primary inertia forces of the slider are partially balanced by a revolving mass of 6 kg at the crank, placed at a distance equal to crank radius. Neglect the mass of connecting rod and crank. When the crank angle (with respect to slider axis) is 30°, the unbalanced force (in Newton) normal to the slider axis is ________

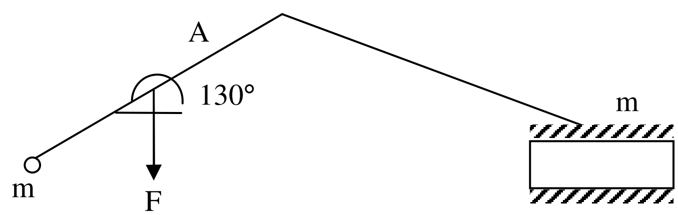
Answer: 29 to 31

Exp: $r = \frac{0.2}{2} = 0.1 \qquad m = 6\text{kg}$

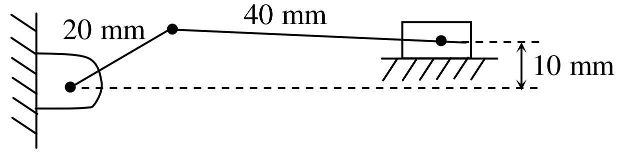
$$F = mr(10^2)\sin\theta$$

$$= 6 \times 0.1 \times 100 \times \sin 30°$$

$$= 30\text{ N}$$



37. An offset slider-crank mechanism is shown in the figure at an instant. Conventionally, the Quick Return Ratio (QRR) is considered to be greater than one. The value of QRR is ________



Answer: 1.2 to 1.3

Exp:

$AB = \text{stroke length}$

$AO = 40 - 20 = 20$

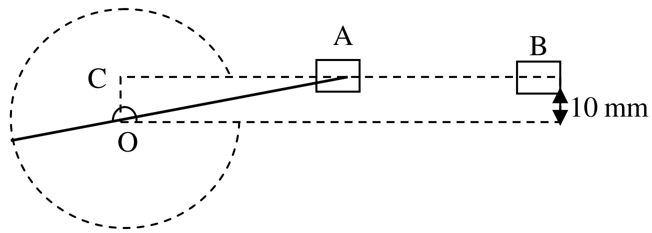
$BO = 40 + 20 = 60$

$\angle AOB = \angle BOC - \angle AOC$

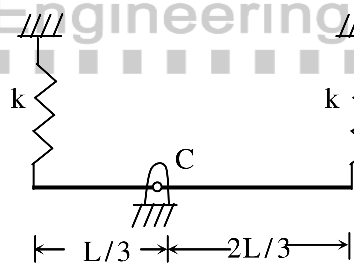
$= 80.41 - 60$

$= 20.41$

$QRR = \dfrac{180+\phi}{180-\phi} = 1.255.$



Q.38 A rigid uniform rod *AB* of length *L* and mass *m* is hinged at *C* such that *AC* = *L*/3, *CB* = 2*L*/3. Ends *A* and *B* are supported by springs of spring constant *k*. The natural frequency of the system is given by



(A) $\sqrt{\dfrac{k}{2m}}$ (B) $\sqrt{\dfrac{k}{m}}$ (C) $\sqrt{\dfrac{2k}{m}}$ (D) $\sqrt{\dfrac{5k}{m}}$

Answer: (D)

39. A hydrodynamic journal bearing is subject to 2000 N load at a rotational speed of 2000 rpm. Both bearing bore diameter and length are 40 mm. If radial clearance is $20\mu m$ and bearing is lubricated with an oil having viscosity 0.03 Pa.s, the Sommerfeld number of the bearing is ________

Answer: 0.75 to 0.85

Exp: $S = \left(\dfrac{r}{c}\right)^2 \dfrac{\mu D_s}{P}$

$d = 40\text{ mm} \Rightarrow r = 20\text{ mm}$

$c = 20\,\mu\text{m} \Rightarrow c = 20\times10^{-3}\text{ mm}$

$\mu = 0.03\text{ PaS} \Rightarrow \mu = 0.03\times10^{-6}\text{ MPa.S}$

$D_S = 2000\text{ rpm} \Rightarrow D_S = \dfrac{2000}{60}\text{ rps}$

$P = \dfrac{p}{1\times d} = \dfrac{2000}{40\times40} = 1.25\text{ MPa}$

$$S = \left(\frac{20}{20\times10^{-3}}\right)^2 \times \frac{0.03\times10^{-6}\times\frac{2000}{60}}{1.25} = 0.8.$$

40. A 200 mm long, stress free rod at room temperature is held between two immovable rigid walls. The temperature of the rod is uniformly raised by 250°C. If the Young's modulus and coefficient of thermal expansion are 200 GPa and 1×10^{-5} /°C, respectively, the magnitude of the longitudinal stress (in MPa) developed in the rod is _______

Answer: 499 to 501

Exp: $l = 200,\ \Delta T = 250°C,\quad \alpha = 1\times10^{-5}\,/°C$

$E = 200\text{ GPa} = 200\times10^{3}\text{ MPa}$

$\sigma = \alpha\Delta TE$

$= 1\times10^{-5}\times250\times200\times10^{3}$

$= 500\text{ MPa}.$

41. 1.5 kg of water is in saturated liquid state at 2 bar (v_f = 0.001061 m^3/kg, u_f = 504.0 kJ/kg, h_f = 505 kJ/kg). Heat is added in a constant pressure process till the temperature of water reaches 400°C (v = 1.5493 m^3 / Kg, u = 2967.0 kJ/kg, h = 3277.0 kJ/kg). The heat added (in kJ) in the process is _______

Answer: 4155 to 4160

Exp: Given, $m = 1.5\text{ kg}$

$h_1 = h_f = 505\text{ kJ/kg} \qquad h_2 = 3277.0$

From Ist Law,

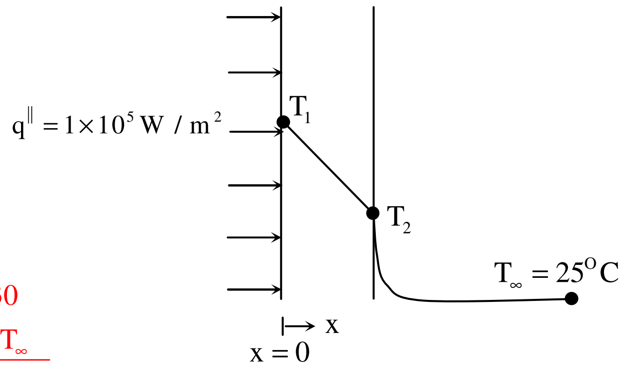
$dQ = du + pdv = dh - vdp$

$dQ = dh \quad (\text{as} \quad vdp = 0)$

$Q_{add} = dQ = m(h_2 - h_1) = (3277.0 - 505)\times1.5$

$Q_{added} = 4158\text{ kJ}.$

42. Consider one dimensional steady state heat conduction across a wall (as shown in figure below) of thickness 30 mm and thermal conductivity 15 W/m.K. At $x = 0$, a constant heat flux, $q'' = 1 \times 10^5$ W/m^2 is applied. On the other side of the wall, heat is removed from the wall by convection with a fluid at 25^{O}C and heat transfer coefficient of 250 W/m^2.K. The temperature (in ^{O}C), at $x = 0$ is _______



Answer: 620 to 630

Exp: $Q = \dfrac{T - T_\infty}{\dfrac{L}{kA} + \dfrac{1}{hA}}$

$q = \dfrac{Q}{A} = \dfrac{T - T_\infty}{\dfrac{L}{k} + \dfrac{1}{h}}$

$1\times10^5 = \dfrac{T - 25}{\dfrac{30\times10^{-3}}{15} + \dfrac{1}{250}}$

$600 = T - 25°C$

$T = 625°C.$

43. Water flows through a pipe having an inner radius of 10 mm at the rate of 36 kg/hr at 25^{O}C. The viscosity of water at 25^{O}C is 0.001 kg/m.s. The Reynolds number of the flow is _______

Answer: 635 to 638

Exp: given $Q = 36\ kg/hr$

$1m^3/hr = 1000\,kg/hr$

so converting kg/hr to m^3/s

$Q = 10^{-5}\ m^3/s$

$R_e = \dfrac{\rho VD}{\mu} = \dfrac{\rho D}{\mu} \times \dfrac{Q}{A}$

$= \dfrac{\rho D}{\mu} \times \dfrac{Q}{\frac{\pi}{4}D^2} = \dfrac{4\rho Q}{\mu D \pi} = \dfrac{4\times1000\times10^{-5}}{0.001\times20\times10^{-3}\times\pi}$

$R_e = 636.62.$

44. For a fully developed flow of water in a pipe having diameter 10 cm, velocity 0.1 m/s and kinematic viscosity 10^{-5} m^2/s, the value of Darcy friction factor is _______

Answer: 0.06 to 0.07

Exp: Given ,D = 10 cm = 0.1 m

$V = 0.1$ m/s

$\nu = 10^{-5}$ m^2/s

$$R_e = \frac{VD}{\nu} = \frac{0.1 \times 0.1}{10^{-5}}$$

$$R_e = 1000$$

$\therefore$ flow is laminar

$$\text{Darcy friction factor} = \frac{64}{R_e}(\text{for laminar flow}) = \frac{64}{1000} = 0.064.$$

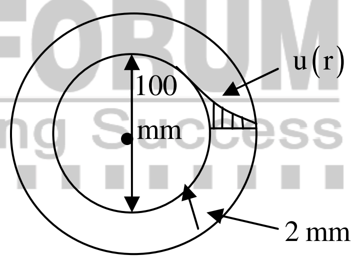
45. In a simple concentric shaft-bearing arrangement, the lubricant flows in the 2 mm gap between the shaft and the bearing. The flow may be assumed to be a plane Couette flow with zero pressure gradient. The diameter of the shaft is 100 mm and its tangential speed is 10 m/s. The dynamic viscosity of the lubricant is 0.1 kg/m.s. The frictional resisting force (in Newton) per 100 mm length of the bearing is _______

Answer: 15 to 16

Exp: $$\tau_w = \tau_{cylinder} = \mu \left.\frac{du}{dr}\right|$$

$$F = A \times \mu \frac{du}{dr}$$

$$= \frac{\pi D \mu [u_t - u_w]}{(\Delta t)}$$



u_t = tangential velocity

u_w = velocity at bearing

$$F = \pi \times 0.1 \times 0.1 \times \frac{0.1[10-0]}{2 \times 10^{-3}}$$

$$F = 15.707 \text{ N.}$$

46. The non-dimensional fluid temperature profile near the surface of a convectively cooled flat plate is given by $\frac{T_W - T}{T_W - T_\infty} = a + b\frac{y}{L} + c\left(\frac{y}{L}\right)^2$, where y is measured perpendicular to the plate, L is the plate length, and a, b and c are arbitrary constants. T_W and T_∞ are wall and ambient temperatures, respectively. If the thermal conductivity of the fluid is k and the wall heat flux is q'', the Nusselt number $Nu = \frac{q''}{T_w - T_\infty}\frac{L}{k}$ is equal to

(A) a (B) b (C) 2c (D) $(b + 2c)$

Answer: (B)

Exp: $$\frac{T_w - T}{T_w - T_\infty} = a + \frac{by}{L} + c\left(\frac{y}{L}\right)^2$$

$$T = T_w + (T_\infty - T_w)\left[a + \frac{by}{L} + c\left(\frac{y}{L}\right)^2\right]$$

$$q'' = -k\frac{dT}{dy} = -k(T_\infty - T_w)\left[\frac{b}{L} + \frac{2Cy}{L^2}\right]$$

at $y = 0$

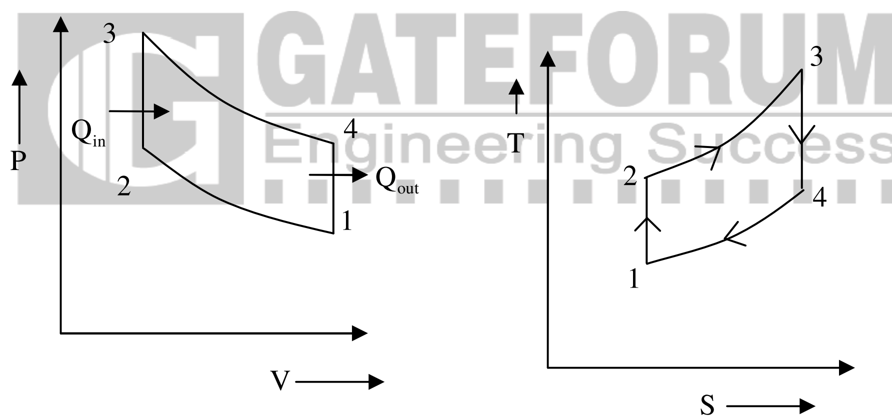
$$\Rightarrow \frac{q'' L}{(T_w - T_\infty)k} = b = N_u$$

$Nu = b.$

47. In an air-standard Otto cycle, air is supplied at 0.1 MPa and 308 K. The ratio of the specific heats (γ) and the specific gas constant (R) of air are 1.4 and 288.8 J/kg.K, respectively. If the compression ratio is 8 and the maximum temperature in the cycle is 2660 K, the heat (in kJ/kg) supplied to the engine is _______

Answer: 1400 to 1420

Exp: Otto cycle



(1-2) Isentropic compression

$PV^r = \text{constant}$

$$\frac{T_2}{T_1} = (r)^{\gamma-1}$$

$T_2 = 308 \times 8^{0.4}$

$= 698.40\ \text{k}$

Given :

$P_1 = 0.1\ \text{MPa}$

$T_1 = 308\ \text{K}$

$r = 1.4$

$R = 0.2888\ \text{kJ/kg.k}$

$T_3 = 2660\ \text{K}$

(2-3) Isochoric Heat addition process

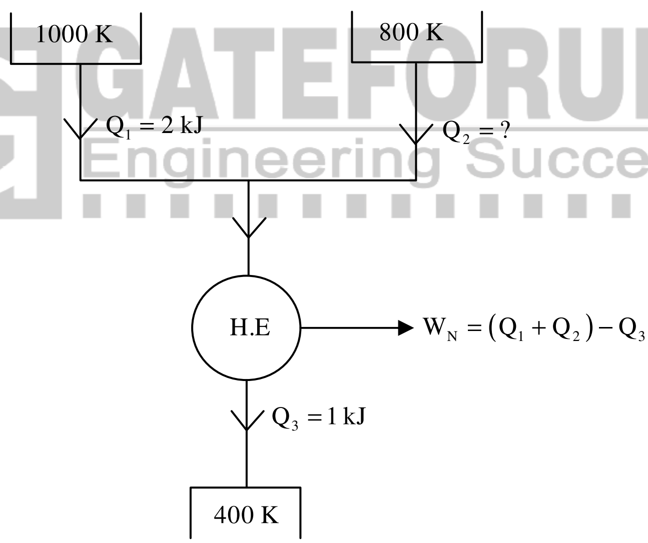
$$\frac{C_P}{C_V} = 1.4$$
$$R = 0.2888\ \text{kJ/kg}$$
$$C_P - C_V = 0.2888$$
$$C_V\left(\frac{C_P}{C_V} - 1\right) = 0.2888$$
$$C_V = \frac{0.2888}{1.4 - 1}$$
$$0.722\ \text{kJ/kg}$$
$$Q_{in} = C_V(T_3 - T_2) = 0.722(2660 - 698.40) = 1416.27\ \text{kJ/kg}$$

48. A reversible heat engine receives 2 kJ of heat from a reservoir at 1000 K and a certain amount of heat from a reservoir at 800 K. It rejects 1 kJ of heat to a reservoir at 400 K. The net work output (in kJ) of the cycle is

(A) 0.8 (B) 1.0 (C) 1.4 (D) 2.0

Answer: (C)

Exp:



We know that for reversible heat engine change in entropy is always zero

That is $\Delta S = 0$

$$\frac{Q_3}{T_3} - \left(\frac{Q_1}{T_1} + \frac{Q_2}{T_2}\right) = 0$$
$$\frac{1}{400} - \frac{2}{1000} - \frac{Q_2}{800} = 0$$
$$Q_2 = 0.4\ \text{kJ}$$
$$W_N = (Q_1 + Q_2) - Q_3$$
$$= (2 + 0.4) - 1 = 1.4\ \text{kJ.}$$

49. An ideal reheat Rankine cycle operates between the pressure limits of 10 KPa and 8 MPa, with reheat being done at 4 MPa. The temperature of steam at the inlets of both turbines is 500°C and the enthalpy of steam is 3185 kJ/kg at the exit of the high pressure turbine and 2247 kJ/kg at the exit of low pressure turbine. The enthalpy of water at the exit from the pump is 191 kJ/kg .Use the following table for relevant data.

Superheated steam temperature	Pressure (MPa)	v (m^3/kg)	h (kJ/kg)	s $(kJ/kg.K)$
(^{O}C)	4	0.08644	3446	7.0922
500	4	0.04177	3399	6.7266

Disregarding the pump work, the cycle efficiency (in percentage) is ________

Answer: 40 to 42

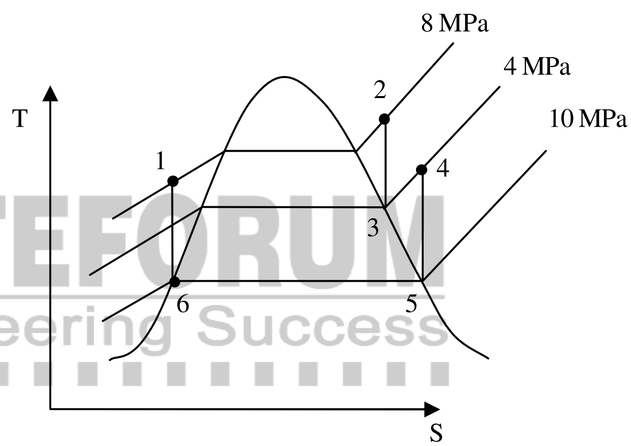
Exp: $w_{HP} = h_2 - h_3$

$w_{LP} = h_4 - h_5$

net work

$w_T = w_{HP} + w_{LP}$

$= (h_2 - h_3) + (h_4 - h_5)$



Given:

$h_1 = 191\ kJ/kg$

$h_2 = 3399\ kJ/kg$

$h_3 = 3185\ kJ/kg$

$h_4 = 3446\ kJ/kg$

$h_5 = 2247\ kJ/kg$

$$\eta_{cycle} = \frac{w_{net}}{Q_{added}}$$

$$\eta_{cycle} = \frac{w_1 - w_{pump}}{Q_{add}}$$

$$\eta_{cycle} = \frac{(h_2 - h_3) + (h_4 - h_5)}{(h_2 - h_1) + (h_4 - h_3)}$$

$$\eta_{cycle} = 0.407 = 40.7\%.$$

50. Jobs arrive at a facility at an average rate of 5 in an 8 hour shift. The arrival of the jobs follows Poisson distribution. The average service time of a job on the facility is 40 minutes. The service time follows exponential distribution. Idle time (in hours) at the facility per shift will be

(A) $\frac{5}{7}$ (B) $\frac{14}{3}$ (C) $\frac{7}{5}$ (D) $\frac{10}{3}$

Answer: (B)

Exp: Arrival Rate = 5 jobs in 8 hrs

Service time = 40 min/Job

$\therefore$ Total service time $= 40\times5 = 200\text{ min} = \frac{200}{60} = \frac{10}{3}\text{hrs}$

$\therefore$ Idle Time/shift $= 8 - \frac{10}{3} = \frac{24-10}{3} = \frac{14}{3}\text{hrs.}$

51. A metal rod of initial length L_0 is subjected to a drawing process. The length of the rod at any instant is given by the expression, $L(t) = L_o(1+t^2)$ where t is the time in minutes. The true strain rate (in min^{-1}) at the end of one minute is ________

Answer: 0.9 to 1.1

Exp: $\varepsilon = \ln\frac{l_i}{l_0}$

$$\frac{d\varepsilon}{dt} = \frac{l_0}{l_i}\times\frac{1}{l_0}\frac{dl_i}{dt} = \frac{2t}{(1+t^n)}$$

$$\frac{d\varepsilon}{dt} = \frac{2\times1}{1+1} = 1.$$

52. During pure orthogonal turning operation of a hollow cylindrical pipe, it is found that the thickness of the chip produced is 0.5 mm. The feed given to the zero degree rake angle tool is 0.2 mm/rev. The shear strain produced during the operation is ________

Answer: 2.8 to 3.0

Exp: Chip thickness ratio $r = \frac{0.2}{0.5} = \frac{t_1}{t_2}$

$$\tan\phi = \frac{r\cos\alpha}{1-r\sin\alpha} = 0.4$$

$$\phi = 21.8°$$

Shear strain $= \cot\phi + \tan(\phi-\alpha) = \cot 21.8 + \tan(21.8-\alpha) = 2.9.$

53. For the given assembly: 25 H7/g8, match Group A with Group B

Group A	Group B
(P) H	(I) Shaft Type
(Q) IT8	(II) Hole Type
(R) IT7	(III) Hole Tolerance Grade
(S) g	(IV) Shaft Tolerance Grade

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

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

Answer: (D)

Exp: H7 is for hole where 7 indicates its tolerance grade

g8 is for shaft where 8 indicates its tolerance grade

54. If the Taylor's tool life exponent n is 0.2, and the tool changing time is 1.5 min, then the tool life (in min) for maximum production rate is _______

Answer: 5.9 to 6.1

Exp: $T_{opt} = \left[\frac{1-n}{n} \times T_C\right] = \frac{1-0.2}{0.2} \times 1.5 = 6 \text{ min}.$

55. An aluminium alloy (density 2600 kg/m^3) casting is to be produced. A cylindrical hole of 100 mm diameter and 100 mm length is made in the casting using sand core (density 1600 kg/ m^3). The net buoyancy force (in Newton) acting on the core is _______

Answer: 7 to 8

Exp: $d = 1600 \text{ kg}/\text{m}^3$

$\rho = 2600 \text{ kg}/\text{m}^3$

Net buouancy force = weight of liquid displaced − weight of solid body

$= v \times \rho \times g - v \times d \times g = vg(\rho - d)$

$= \frac{\pi}{4} d^2 L \times g(\rho - d)$

$= \frac{\pi}{4} 0.1^2 \times 0.1 \times 9.81(2600 - 1600) = 7.7\text{N}.$