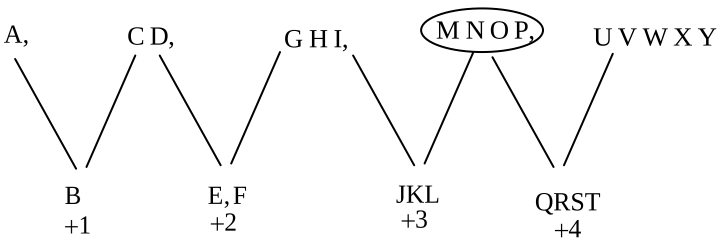
General Aptitude

Q. No. 1 – 5 Carry One Mark Each

1. Find the missing sequence in the letter series below:
A, CD, GHI,?, UVWXY
(A) LMN (B) MNO (C) MNOP (D) NOPQ

Answer: (C)

Exp:



2. Choose the correct verb to fill in the blank below:
Let us _______________.
(A) Introvert (B) alternate (C) atheist (D) altruist

Answer: (B)

3. Choose the most appropriate word from the options given below to complete the following sentence?
If the athlete had wanted to come first in the race, he ___________several hours every day.
(A) Should practice (B) Should have practiced
(C) Practised (D) Should be practicing

Answer: (B)

Exp: For condition regarding something which already happened, should have practiced is the correct choice.

4. Choose the most suitable one word substitute for the following expression
Connotation of a road or way
(A) Pertinacious (B) Viaticum
(C) Clandestine (D) Ravenous

Answer: (B)

Exp: Viaticum and connotation both are associated with the feeling of spirtuality.

5. If x>y>I, which of the following must be true?
(i) $\ln x > \ln y$ (ii) $e^x > e^y$ (iii) $y^x > x^y$ (iv) $\cos x > \cos y$
(A) (i) and (ii) (B) (i) and (iii)
(C) (iii) and (iv) (D) (ii) and (iv)

Answer: (A)

Exp: For whole numbers, greater the value greater will be its log.
Same logic for power of e.

Q. No. 6 – 10 Carry Two Marks Each

6. From a circular sheet of paper of radius 30cm, a sector of 10% area is removed. If the remaining part is used to make a conical surface, then the ratio of the radius and height of the cone is________.

Answer: 2.06

Exp: 90% of area of sheet = Cross sectional area of cone

$\Rightarrow 0.9\times\pi\times 30\times 30=\pi\times r_1\times 30$

$\Rightarrow 27\text{ cm}=r_1$

$\therefore$ Height of the cone $=\sqrt{30^2-27^2}$

$=13.08\text{ cm}$

Then r/h=27/13.08=2.06

7. In the following question, the first and the last sentence of the passage are in order and numbered 1 and 6. The rest of the passage is split into 4 parts and numbered as 2,3,4, and 5. These 4 parts are not arranged in proper order. Read the sentences and arrange them in a logical sequence to make a passage and choose the correct sequence from the given options.

1. One Diwali, the family rises early in the morning.
2. The whole family, including the young and the old enjoy doing this,
3. Children let off fireworks later in the night with their friends.
4. At sunset, the lamps are lit and the family performs various rituals
5. Father, mother, and children visit relatives and exchange gifts and sweets.
6. Houses look so pretty with lighted lamps all around.

(A) 2, 5, 3, 4 (B) 5, 2, 4, 3 (C) 3, 5, 4,2 (D) 4, 5, 2, 3

Answer: (B)

8. Ms X will be in Bagdogra from 01/05/2014 to 20/05/2014 and from 22/05/2014 to 31/05/2014. On the morning of 21/05/204, she will reach Kochi via Mumbai

Which one of the statements below is logically valid and can be inferred from the above sentences?

(A) Ms. X will be in Kochi for one day, only in May
(B) Ms. X will be in Kochi for only one day in May
(C) Ms. X will be only in Kochi for one day in May
(D) Only Ms. X will be in Kochi for one day in May.

Answer: (B)

9. $\log\tan 1^{O}+\log\tan 2^{O}+......+\log\tan 89^{O}$ is ....

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

Answer: (C)

Exp: $\log\tan 1^{o} + \log\tan 89^{o} = \log\left(\tan 1^{o} \times \tan 89^{o}\right)$

$$= \log\left(\tan 1^{o} \times \cot 1^{o}\right)$$
$$= \log 1$$
$$= 0$$

Using the same logic total sum is '0'.

10. Ram and Shyam shared a secret and promised to each other that it would remain between them. Ram expressed himself in one of the following ways as given in the choices below. Identify the correct way as per standard English.
    (A) It would remain between you and me.
    (B) It would remain between I and you
    (C) It would remain between you and I
    (D) It would remain with me.

Answer: (A)

Mechanical Engineering

Q. No. 1 – 25 Carry One Mark Each

1. The uniaxial yield stress of a material is 300 MPa. According to von Mises criterion, the shear yield stress (in MPa) of the material is _______

Answer: 173.28

Exp. If there is uniaxial loading yield stress is σ_y

As per Von Mises failure theory

$$\sigma_y{}^2 = \sigma_1^2 + \sigma_1\sigma_2 + \sigma_2{}^2$$

Under pure shear stress loading

$$\sigma_1 = -\sigma_2 = \tau$$

then

$$\sigma_y{}^2 = \tau^2 + \tau^2 + \tau^2$$
$$= 3\tau^2$$
$$\Rightarrow \tau = \frac{\sigma_y}{\sqrt{3}} \text{ hence } \tau = \frac{\sigma_y}{\sqrt{3}} = 0.577\sigma_y = 173.28$$

where τ is shear yield stress

2. The primary mechanism of material removal in electrochemical machining (ECM) is
   (A) Chemical corrosion
   (B) etching
   (C) ionic dissolution
   (D) spark erosion

Answer: (C)

3. Curl of vector V(x,y,z) = $2x^2 i + 3z^2 j + y^3 k$ at $x = y = z = 1$ is

(A) $-3i$ (B) $3i$ (C) $3i - 4j$

(D) $3i - 6k$

Answer: (A)

Exp: Curl of $V(x,y,z) = \begin{vmatrix} i & j & k \\ \frac{\partial}{\partial x} & \frac{\partial}{\partial y} & \frac{\partial}{\partial z} \\ 2x^2 & 3z^2 & y^3 \end{vmatrix}$

$= i\left[3y^2 - 6z\right] + j[0-0] + k[0-0]$

$= \left(3y^2 - 6z\right)i\Big|_{x=y=z=1}$

$= -3i$

4. A small ball of mass 1kg moving with a velocity of 12m/s undergoes a direct central impact with a stationary ball of mass 2 kg. The impact is perfectly elastic. The speed (in m/s) of 2 kg mass ball after the impact will be ________

Answer: 8

Exp: For elastic collision

$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$ (1) __________ moment conservation

$m_1 = 1$ kg $u_1 = 12$ m/s

$m_2 = 2$ kg $u_2 = 0$ m/s

$\frac{1}{2}m_1u_1^2 + \frac{1}{2}m_2u_2^2 = \frac{1}{2}m_1v_1^2 + \frac{1}{2}m_2v_2^2 (2)$____ energy conservation

From (1) equation

$12 = v_1 + 2v_2$ _________(3)

From (2) equation

$\frac{1}{2}\times1\times144 + \frac{1}{2}\times2\times0 = \frac{1}{2}\times1\times v_1^2 + \frac{1}{2}\times2\times v_2^2$

$\Rightarrow 144 = v_1^2 + 2v_2^2$ ____(4)

From (3) and (4)

$144 = 144 + 4v_2^2 - 48v_2 + 2v_2^2$

$\Rightarrow 6v_2^2 - 48v_2 = 0$

$6v_2\left(v_2 - 8\right) = 0$

$\Rightarrow v_2 = 8\,m/s$

5. A rod is subjected to a unit-axial load within linear elastic limit. When the change in the stress is 200 MPa, the change in the strain is 0.001. If the Poisson's ratio of the rod is 0.3, the modulus of rigidity (in GPa) is ____________

Answer: 77

Exp: Modulus of rigidity (G)

$$G = \frac{E}{2(1+\mu)}$$

It has given change in stress = 200 MPa

Change in strain = 0.001

Here

200 = E×0.003

$$\Rightarrow E = \frac{200\,MPa}{0.002} = 200\times10^3\,MPa$$

$$= 200\,GPa$$

$$G = \frac{200}{2(1+0.3)} = \frac{200}{2\times1.3} = \frac{100}{1.3} = \frac{1000}{13} = 77\,GPa$$

6. Within a boundary layer for a steady incompressible flow, the Bernoulli equation

(A) holds because the flow is steady

(B) holds because the flow is incompressible

(C) holds because the flow is transitional

(D) does not hold because the flow is frictional

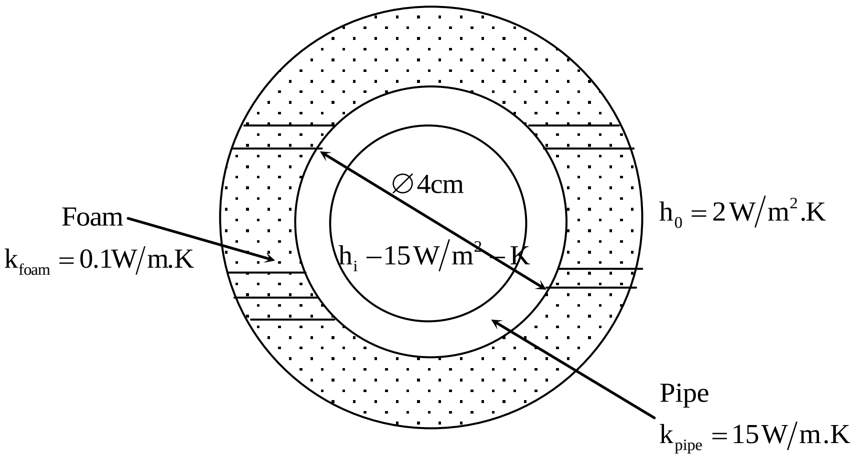
Answer: (D)

Exp: Bernoulli equation does not hold because it is for non viscous flow

7. The atomic packing factor for a material with body centered cubic structure is _______

Answer: 0.64

8. If a foam insulation is added to a 4cm outer diameter pipe as shown in the figure, the critical radius of insulation (in cm) is ____________



Answer: 5

Exp: Critical radius $r_c = \frac{k}{h_0} = \frac{0.1}{2} = .05\,m$

$= 5\,cm$

9. During the development of a product an entirely new process plan is made based on design logic, examination of geometry and tolerance information. This type of process planning is known as

(A) Retrieval (B) Generative

(C) Variant (D) Group technology based

Answer: (B)

10. Annual demand of a product is 50000 units and the ordering cost is Rs. 7000 per order considering the basic economic order quantity model, the economic order quantity is 10000 units. When the annual inventory cost is minimized, the annual inventory holding cost (in Rs.) is ________

Answer: 35000

Exp: At optimum total inventory cost (TIC), annual inventory hold is cost is equal to annual inventory ordering cost

= Number of orders × ordering cost per order

$= \frac{50000}{10000} \times 7000$

$= 5 \times 7000$

$= 35000$

11. Sales data of a product is given in the following table:

Month	January	February	March	April	May
Number of unit sold	10	11	16	19	25

Regarding forecast for the month of June, which one of the following statements is **TRUE?**

(A) Moving average will forecast a higher value compared to regression

(B) Higher the value of order N, the greater will be the forecast value by moving average.

(C) Exponential smoothing will forecast a higher value compared to regression.

(D) Regression will forecast a higher value compared to moving average

Answer: (D)

12. The Vander Waals equation of state is $\left(p + \frac{a}{v^2}\right)(v - b) = RT,$ where p is pressure, v is specific volume, T is temperature and R is characteristic gas constant. The SI unit of a is

(A) $J/kg.K$ (B) m^3/kg (C) $m^5/kg - s^2$ (D) Pa/kg

Answer: (C)

Exp: $p+\frac{a}{v^2}$ both term should gave same unit since they are getting added

$$\Rightarrow \frac{N}{m^2}=a\left(\frac{kg}{m^3}\right)^2$$

$$\Rightarrow a(\text{unit})=\frac{m^6}{kg^2}.kg.\frac{m}{s^2m^2}=\frac{m^5kg}{kg^2s^2}=\frac{m^5}{kg\,s^2}$$

13. Which of the following statements regarding a Rankine cycle with reheating are TRUE?

(i) increase in average temperature of heat addition

(ii) reduction in thermal efficiency

(iii) drier steam at the turbine exit

(A) only (i) and (ii) are correct
(B) only (ii) and (iii) are correct
(C) only (i) and (iii) are correct
(D) (i), (ii) and (iii) are correct

Answer: (C)

Exp: With reheat average temperature of heat addition increases. Hence, efficiency of cycle also increases. Further, the quality of steam is higher at turbine exit.

14. In a spring-mass system, the mass is m and the spring constant is k. The critical damping coefficient of the system is 0.1kg/s. In another spring-mass system, the mass is 2m and the spring constant is 8K. The critical damping coefficient (in kg/s) of this system is ___________

Answer: 0.4

Exp: $\omega_{n1}=\frac{C_{C1}}{2m_1}$

$$C_{C1}=2\sqrt{K_1m_1}=2\sqrt{Km}$$

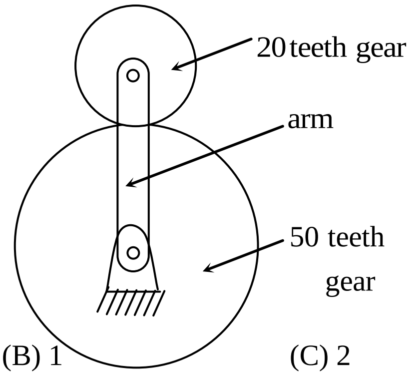
$$C_{C2}=2\sqrt{K_2m_2}=2\sqrt{8K\times 2m}=4C_{C1}=4\times 0.1=0.4$$

15. The COP of a cannot heat pump operating between $6^{O}C$ and $37^{O}C$ is ____________

Answer: 10

Exp: $(COP)_{c.p.}=\frac{T_1}{T_1-T_2}=\frac{310}{31}=10$

16. The number of degrees of freedom of the planetary gear train shown in the figure is



(A) 0 (B) 1 (C) 2 (D) 3

Answer: (C)

Exp: A planetary gear train has 2 DOF and hence requires too input to get desired output.

17. A rope-brake dynamometer attached to the crank shaft of an I.C. engine measures a brake power of 10kW when the speed of rotation of the shaft is 400 rad/s. The shaft torque (in N-m) sensed by the dynamometer is ________

Answer: 25

Exp: $P = T\omega$

$$T = \frac{10000}{400} = 25\,N-m$$

18. At least one eigen value of a singular matrix is

(A) Positive (B) Zero (C) Negative (D) Imaginary

Answer: (B)

19. If the fluid velocity for a potential flow is given by $V(x,y) = u(x,y)i + v(x,y)j$ with usual notations, then the slope of the potential line at (x,y) is

(A) $\frac{v}{u}$ (B) $-\frac{u}{v}$ (C) $\frac{v^2}{u^2}$ (D) $\frac{u}{v}$

Answer: (B)

Exp:

$$d\phi = \frac{\partial\phi}{\partial x}dx + \frac{\partial\phi}{\partial y}dy$$

$$d\phi = udx + vdy$$

$$\frac{dy}{dx} = -\frac{u}{v}$$

20. Which one of the following statements is TRUE?

(A) The 'GO' gage controls the upper limit of a hole

(B) The 'NO' gage controls the lower limit of a shaft

(C) The 'GO' gage controls the lower limit of a hole

(D) The 'NO GO' gage controls the lower limit of a hole

Answer: (C)

Exp: Go size = maximum material limit of component = Lower limit of hole

21. There vendors were asked to supply a very high precision component. The respective probabilities of their meeting the strict design specifications are 0.8, 0.7 and 0.5. Each vendor supplies one component. The probability that out of total three components supplied by the vendors, at least one will meet the design specification is __________

Answer: 0.97

Exp: Probability (at least one will meet specification) = 1-probability (none will meet specification)

= 1-(1-0.8)×(1-0.7)×(1-0.5)

= 1-0.2×0.3×0.5

= 1-0.03

= 0.97

22. The Laplace transform of e^{i5t} where $i=\sqrt{-1}$, is

(A) $\frac{s-5i}{s^2-25}$ (B) $\frac{s+5i}{s^2+25}$ (C) $\frac{s+5i}{s^2-25}$ (D) $\frac{s-5i}{s^2+25}$

Answer: (B)

Exp:
$$L\left\{e^{i5t}\right\}=L\left(\cos 5t+i\sin 5t\right)$$
$$=L\left(\cos 5t\right)+iL\left(\sin 5t\right)=\frac{s+5i}{s^2+25}$$

23. A gas is stored in a cylindrical tank of inner radius 7 m and wall thickness 50 mm. The gage pressure of the gas is 2MPa. The maximum shear stress (in MPa) in the wall is

(A) 35 (B) 70 (C) 140 (D) 280

Answer: (C)

Exp:
$$\sigma_1=\frac{pd}{2t}=\frac{2\times 14}{2\times 0.05}=280\,\text{MPa}$$
$$\sigma_2=\frac{pd}{4t}=\frac{2\times 14}{4\times 0.05}=140\,\text{MPa}$$
$$\sigma_3=0$$
$$\text{Maximum shear stress}=\text{Maximum}\left\{\left|\frac{\sigma_1-\sigma_2}{2}\right|,\left|\frac{\sigma_2-\sigma_3}{2}\right|,\left|\frac{\sigma_3-\sigma_1}{2}\right|\right\}=140\text{MPa}$$

24. In the laminar flow of air $(Pr = 0.7)$ over a heated plate if δ and δ_T denote, respectively, the hydrodynamic and thermal boundary layer thicknesses, then

(A) $\delta = \delta_T$ (B) $\delta > \delta_T$ (C) $\delta < \delta_T$ (D) $\delta = 0$ but $\delta_T \neq 0$

Answer: (C)

Exp: When

$P_r < 1$ $\delta_t > \delta$

$P_r > 1$ $\delta_t < \delta$

$P_r = 1$ $\delta_t = \delta$

25. At x = 0, the function f(x) = $|x|$ has

(A) A minimum (B) A maximum

(C) A point of inflexion (D) neither a maximum nor minimum

Answer: (A)

Exp: For negative values of x, f(x) will be positive

For positive values of x, f(x) will be positive

∴ minimum value of f(x) will occur at x = 0

26. The total emissive power of a surface is 500 W/m^2 at a temperature T_1 and 1200 W/m^2 at a temperature T_2. Where the temperatures are in Kelvin. Assuming the emissivity of the surface to be constant, the ratio of the temperatures $\frac{T_1}{T_2}$ is

(A) 0.308 (B) 0.416 (C) 0.803 (D) 0.874

Answer: (C)

Exp: If temperature is T_1 then

Emissive power $\propto T_1^4$

$500 \propto T_1^4$ ___(1)

or

$500 = k\,T_1^4$ ___(1)

similarly

$1200 = kT_2^4$ ___(2)

from (1)/(2)

$$\left(\frac{T_1}{T_2}\right)^4 = \frac{500}{1200}$$

$$\frac{T_1}{T_2} = \left(\frac{500}{1200}\right)^{1/4} = 0.803$$

27. A hallow shaft of 1m length is designed to transmit a power of 30 kW at 700 rpm. The maximum permissible angle of twist in the shaft is 1^{O}. The inner diameter of the shaft is 0.7

times the outer diameter. The modulus of rigidity is 80 GPa. The outside diameter (in mm) of the shaft is ________

Answer: 44.52

Exp: $P = T\omega$

$$30 \times 1000 = T \times \frac{2\pi \times 700}{60}$$

$$\therefore T = 409.256\,N-m$$

$$\frac{T}{I_P} = \frac{G\theta}{l}$$

$$\frac{409.256}{\frac{\pi}{32}\left(1-0.7^4\right)d_0^4} = \frac{80 \times 10^9}{1} \times \frac{\pi}{180} \quad \left(\begin{array}{c} l = 1m \\ \theta = \frac{\pi}{180}\text{radians} \end{array}\right)$$

Solving, we get

$d_0 = 44.5213$ mm

28. In a Rankine cycle, the enthalpies at turbine entry and outlet are 3159kJ/kg. and 2187 kJ/kg, respectively. If the specific pump work is 2kJ/kg the specific steam consumption (in kg/kW-h) of the cycle based on net output is ___________

Answer: 3.71

Exp: Specific steam consumption $= \dfrac{3600}{W_T - W_P}$

$W_T = h_2 - h_1 = 3159\text{-}2187$ kJ/kg

$W_T = 972$ kJ/kg

$W_P = 2$ kJ/kg

Thus specific steam consumption $= \dfrac{3600}{972-2}\,\text{kg/kW}-\text{h}$

$= 3.71\,\text{kg/kW.h}$

29. A single point cutting tool with 0^O rake angle is used in an orthogonal machining process. At a cutting speed of 180 m/min, the thrust fore is 490N. If the coefficient of friction between the tool and the chip is 0.7, then the power consumption (in kW) for the machining operation is ___________

Answer: 2.1

Exp: $$\mu = \frac{F}{N} = \frac{F_C \sin\alpha + F_T \cos\alpha}{F_C \cos\alpha - F_T \sin\alpha}$$

$$\text{Given}: \alpha = 0°$$

$$\therefore \mu = \frac{F_T}{F_C}$$

$$0.7 = \frac{490}{F_C}$$

$$\therefore F_C = 700\,N$$

$$\text{Power consumption, } P = F_c \times V_c = 700 \times \frac{180}{60} \times \frac{1}{1000}(kW)$$

$$P = 2.1\,kW$$

30. The chance of a student passing an exam is 20%. The chance of a student passing the exam and getting above 90% marks in it is 5% Given that a student passes the examination, the probability that the student gets above 90% marks is

(A) $\frac{1}{18}$ (B) $\frac{1}{4}$ (C) $\frac{2}{9}$ (D) $\frac{5}{18}$

Answer: (B)

Exp: Let A→student passes the exam

B→student gets above 90% marks

Given P(A) = 20%; P(A∩B) = 5%

$$\text{required probability is } P(B/A) = \frac{P(A \cap B)}{P(A)} = \frac{5\%}{20\%} = \frac{1}{4}$$

31. A manufacturer has the following data regarding a product:

Fixed cost per month = Rs. 50000

Variable cost per unit = Rs.200

Selling price per unit = Rs.300

Production capacity = 1500 units per month

If the production is carried out at 80% of the rated capacity, that the monthly profit (in Rs.) is ________

Answer: 70000

Exp: Profit per month = 0.8 ×1500 × (300-200) – 50000

= 120000-50000

= 70000

32. The head loss for a laminar incompressible flow through a horizontal circular pipe is h_1. Pipe length and fluid remaining the same, if the average flow velocity doubles and the pipe diameter reduces to half its previous value, the head loss is h_2. The ratio h_2/h_1 is

(A) 1 (B) 4 (C) 8 (D) 16

Answer: (C)

Exp: head loss $h \propto \frac{u_{avg}}{D^2}$

$$\therefore \frac{h_2}{h_1} = \left(\frac{D_1}{D_2}\right)^2 \frac{u_{avg,2}}{u_{avg,1}}$$

$$= 2^2 \times 2$$

$$\frac{h_2}{h_1} = 8$$

33. A cube and a sphere made of cat iron (each of volume 1000 cm^3) were cast under identical conditions. The time taken for solidifying the cube was 4s. The solidification time (in s) for the sphere is __________

Answer: 6.15

Exp: $\text{solidification Time} = k\left(\frac{v}{A}\right)^2$

$$\text{for cube, } t = 4 = k.\left(\frac{a^3}{6a^2}\right)^2 = k.\left(\frac{a}{6}\right)^2$$

$$k.\frac{a^2}{36} = 4$$

$$ka^2 = 36 \times 4 \text{ \_\_\_\_\_\_}(1)$$

$$\text{vol. of cube} = \text{vol. of sphere}$$

$$\Rightarrow \frac{4}{3}\pi r^3 = a^3$$

$$\Rightarrow r = \left(\frac{3}{4\pi}\right)^{1/3} a$$

$$\text{solidification time for sphere, } t' = k.\left(\frac{\frac{4}{3}\pi r^3}{4\pi r^2}\right)^2 = \left(\frac{r}{3}\right)^2$$

$$\Rightarrow k\left(\left(\frac{3}{4\pi}\right)^{1/3} .a/3\right)^2$$

$$\Rightarrow k.a^2 \times \left(\frac{3}{4\pi}\right)^{2/3} \times 9$$

$$= 6.1573\text{sec}$$

34. One kg of air (R = 287 J/kg.K) undergoes an irreversible process between equilibrium state 1 $\left(20^{O}C, 0.9m^3\right)$ and equilibrium state 2 (20 ^{O}C, 0.6m^3). The change in entropy $S_2 - S_1$ (in J/kg.K) is __________

Answer: -116.36

Exp: $s_2 - s_1 = mR\ln\frac{V_2}{V_1}$

$= 287\ln\frac{0.6}{0.9} = -116.368\,J/kgK$

35. In a plane stress condition, the components of stress at point are $\sigma_x = 20$ MPa, $\sigma_y = 80\,MPa$ and $\tau_{xy} = 40\,MPa$. The maximum shear stress (in MPa) at the point is

(A) 20 (B) 25 (C) 50 (D) 100

Answer: (C)

Exp: $\tau_{max} = \frac{\sigma_1 - \sigma_2}{2} = \sqrt{\left(\frac{\sigma_x - \sigma_y}{2}\right)^2 + \tau_{xy}^2}$

$= \sqrt{\left(\frac{80-20}{2}\right)^2 + 40^2}$

$= 50\,MPa$

36. Work is done on an adiabatic system due to which its velocity changes from 10 m/s to 20 m/s, elevation increases by 20 m and temperature increases by 1 K. The mass of the system is 10 kg. $C_V = 100\,J/(kg.K)$ and gravitational acceleration is 10 m/s^2. If there is no change in any other component of the energy of the system, the magnitude of total work done (in kJ) on the system is________

Answer: 4.5

Exp: Using SFEE

$$m\left[\left(\frac{v_1^2}{2} - \frac{v_2}{2}\right)^2 + (z_1 - z_2)g + (h_1 - h_2)\right] = W$$

$$10\left[\frac{10^2}{2} - \frac{20^2}{2} + (-20)\times 10 + (100\times -1)\right] = W$$

$W = -4.5\,kJ$

$\therefore$ Work done on the system is 4.5 kJ.

37. A hollow shaft $d_o = 2d_i$ where d_o and d_i are the outer and inner diameters respectively) needs to transmit 20kW power at 3000 RPM. If the maximum permissible shear stress is 30 MPa, d_O is

(A) 11.29 mm (B) 22.58 mm (C) 33.87 mm (D) 45.16 mm

Answer: (B)

Exp: $P = T\omega$

$$20\times10^3 = T\times\frac{2\pi\times3000}{60}$$

$$\therefore T = 63.662\ N-m$$

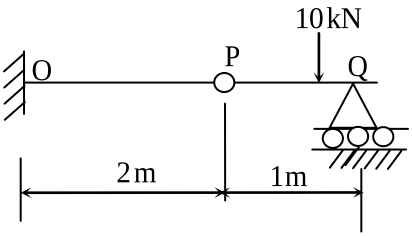
$$\frac{T}{I_p} = \frac{\tau}{r},$$

$$\frac{63.662}{\frac{\pi}{32}(15d_1^4)} = \frac{30\times10^6}{d_1}(r_0 = d),$$

$$\therefore d_1 = 11.295\ mm$$

$$\therefore d_0 = 2d_1 = 22.59\ mm$$

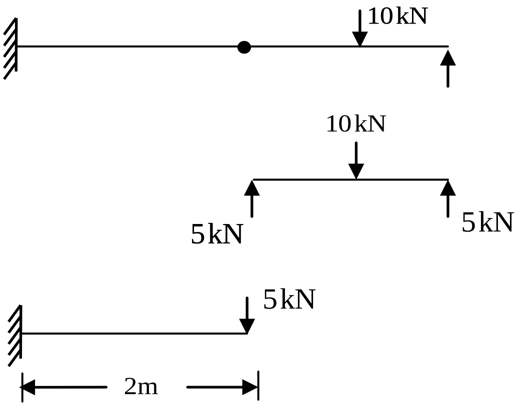
38. A cantilever beam OP is connected to another beam PQ with a pin joint as shown in the figure. A load of 10kN is applied at the mid-point of PQ. The magnitude of bending moment (in kN-m) at fixed end O is \



(A) 2.5 (B) 5 (C) 10 (D) 25

Answer: (C)

Exp:



M = 5 × 2 = 10 kN

39. The flow stress (in MPa) of a material is given by

$$\sigma = 500\varepsilon^{0.1}$$

Where ε is true strain. The Young's modulus of elasticity of the material is 200 GPa. A block of thickness 100 mm made of this material is compressed to 95 mm thickness and then the load is removed. The final dimension of the block (in mm) is _________

Answer: 95.18

Exp: $\text{True strain} = \ln\frac{100}{95} = 0.5129$

$\sigma = 500 \times (0.5129)^{.1} \Rightarrow 371.5147523$

Upto elastic limits using hooks law

$E = \frac{\sigma \times l}{\Delta l}$

$\Rightarrow 200 \times 10^9 = \frac{371.5147523 \times 10^6 \times 100}{\Delta l}$

$\Rightarrow \Delta l = 0.18575\,\text{mm} - \text{considering this for elastic recovery}$

$\therefore$ This will be added to 95 mm

$\Rightarrow$ Final dimension $\Rightarrow$ 95.18575 mm

40. The initial velocity of an object is 40m/s. The acceleration a of the object is given by the following expression: a= 0.1V

Where V is the instantaneous velocity of the object. The velocity of the object after 3 seconds will be _______

Answer: 29.632

Exp: a=-0.1V

$\frac{dv}{dt} = -0.1V$

$\ln v = -0.1t + \ln k$

$V = ke^{-0.1t}$

$\text{at } t = 0;\, V = 40$

$\therefore k = 40$

$V = 40e^{-0.1t}$

$\text{at } t = 3 \text{ seconds}$

$V = 40\,e^{-0.1\times 3} = 29.6327\text{ m/s}$

41. A balanced counter flow heat exchanger has a surface area of $20m^2$ and overall heat transfer coefficient of 20 $W/m^2 - K$ Air $(C_P = 1000 J/kg - K)$ entering at 0.4 kg/s and 280 K is to be preheated by the air leaving the system at 0.4 kg/s and 300 K. The outlet temperature (in K) of the preheated air is

(A) 290 (B) 300 (C) 320 (D) 350

Answer: (A)

Exp: Counter flow heat exchanged

Surface Area $A = 20m^2$

$$u = \frac{20W}{m^2K}$$

$$C_p \text{ of air} = 1000\frac{J}{kgK}$$

mass flowrate $= 0.4\,kg/s$

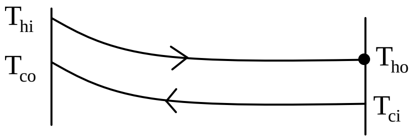
Temperature $T_c i = 280K$

$T_{co} = ?$

Since $\overset{\circ}{m}$ is same for both flow = 0.4 kg/s

Assume C_p is same = 1000 J/kg.K

Hence



$$\Delta T_1 = T_i - T_{\sigma 0} = \Delta T_2 = T_{h0} - T_{ci}$$

$$\Delta T_1 = 300 - T_{co} = T_{ho} - 280$$

$$\Delta T_m = \Delta T_1 = \Delta T_2$$

$$uA\Delta T_m = \overset{\circ}{m} C_p \left(T_{co} - T_{ci}\right)$$

$$20 \times 20 \times \left(300 - T_{co}\right) = 0.4 \times 1000\left(T_{co} - 280\right)$$

$$2T_{co} = 300 + 280$$

$$T_{co} = \frac{580}{2} = 290K$$

42. The values of function f (x) at 5 discrete point are given below:

x	0	0.1	0.2	0.3	0.4
f(x)	0	10	40	90	160

Using Trapezoidal role with step size of 0.1, the value of $\int_0^{0.4} f(x)dx$ is __________

Answer: 22

Exp:

x	0	0.1	0.2	0.3	0.4
$y = f(x)$	0	10	40	90	160
	y_0	y_1	y_2	y_3	y_4

$$\int_0^{0.4} f(x)dx = \int_0^{0.4} ydx = \frac{h}{2}[(y_0 + y_4) + 2(y_1 + y_2 + y_3)]$$
$$= \frac{0.1}{2}[(0+160) + 2(10+40+90)]$$
$$= 22$$

43. In a two-stage wire drawing operation, the fractional reduction (ratio of change in cross-sectional area to initial cross-sectional area) in the first stage is 0.4. The fractional reduction in the second stage is 0.3. The overall fractional reduction is

(A) 0.24 (B) 0.58 (C) 0.60 (D) 1.00

Answer: (A)

Exp: Since only option (A) is less then 0.3. (A) is the correct answer, as overall reduction will be less then the reduction in the first stage.

44. A single-degree. Freedom spring-mass system is subjected to a sinusoidal force of 10 N amplitude and frequency ω along the axis of the spring. The stiffness of the spring is 150 N/m, damping factor is 0.2 and the undamped natural frequency is 10ω. At steady state, the amplitude of vibration (in m) is approximately

(A) 0.05 (B) 0.07 (C) 0.70 (D) 0.90

Answer: (B)

Exp: Amplitude of vibration A= $\dfrac{f_0/s}{\sqrt{1-\left(\frac{\omega}{\omega_n}\right)^2 + \left(\frac{2\xi\omega}{\omega_n}\right)^2}}$

$$= \frac{10/150}{\sqrt{\left[1-\left(\frac{1}{10}\right)^2\right]^2 + \left(2\times 0.2\times\frac{1}{10}\right)^2}}$$
$$= 0.06605$$
$$\simeq 0.07$$

45. For a fully developed laminar flow of water (dynamic viscosity 0.001 Pa-s) through a pipe of radius 5cm. the axial pressure gradient is – 10Pa/m. The magnitude of axial velocity (in m/s) at a radial location of 0.2 cm is ________

Answer: 6.24

Exp: $G = \dfrac{-1}{4\mu}\dfrac{\partial P}{\partial x}\left(R^2 - r^2\right)$

$$= \frac{-1}{4\times 0.001}\times(-10)\left((0.05)^2 - (0.002)^2\right)$$

$u = 6.24\,m/s$

46. In a certain slider-crank mechanism, lengths of crank and connecting rod are equal. If the crank rotates with a uniform angular seed of 14 rad/s and the crank length is 300 mm, the maximum acceleration of the slider (in m/s^2) is ___________

Answer: 117.6

Exp: $a_{max} = 2r\omega^2$ (when $\theta = 0$) i.e at Inner dead centre

$$= 2 \times 0.3 \times 14^2$$

$$a_{max} = 117.6\,m/s^2$$

47. The surface integral $\iint_s \frac{1}{\pi}(9xi - 3yj).ndS$ over the sphere giveb by $x^2 + y^2 + z^2 = 9$ is ____

Answer: 216

Exp: By Gauss divergence theorem,

$$\int_S \bar{F}.\bar{n}\,ds = \int_V div\bar{F}dV$$

Here $\bar{F} = 9x\bar{i} - 3\bar{y}$

div $\bar{F} = 9 - 3 = 6$

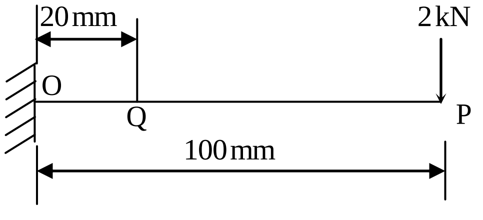
$$\therefore \iint_s \frac{1}{\pi}\left(9x\bar{i} - 3y\bar{j}\right).\bar{n}ds = \frac{1}{\pi}\int_V 6\,dV = \frac{1}{\pi}6V$$

$$= \frac{1}{\pi}6\left(\frac{4}{3}\pi r^3\right)$$

$$= 8(3)^3$$

$$= 216.$$

48. A cantilever beam with square cross-section of 6mm side is subjected to a load of 2kN normal to the top surface as shown in the figure. The young's modulus of elasticity of the material of the beam is 210 GPa. The magnitude of slope. (in radian) at Q (20 mm from the fixed end) is ________



Answer: 0.1587

Exp: Slope. $\theta_Q = \frac{-Px}{2EI}(2L - x)$

where x is measured from the fixed end

$$\therefore \theta_Q = \frac{-2000(0.02)}{2\times 210\times 10^9 \times \frac{(0.006)^4}{12}}(2\times 0.1 - 0.02)$$

=-0.1587

The magnitude of slope is 0.1587 radian

49. A cylindrical uranium fuel rod of radius 5 mm in a nuclear reactor is generating heat at the rate of $4\times 10^7\ W/m^3$. The rod is cooled by a liquid (convective heat transfer coefficient 1000 $W/m^2.K$) at $25^O C$. At steady state, the surface temperature (in K) of the rod is

(A) 308 (B) 398 (C) 418 (D) 448

Answer: (B)

Exp: The surface temp. $(T_w) = T_a + \frac{\dot{q}_g}{2h}R$

$$= 298 + \frac{4\times 10^7}{2\times 1000}\times 5\times 10^{-3}$$

$$T_w = 398\ K$$

50. For the same values of peak pressure, peak temperature and heat rejection, the correct order of efficiencies for Otto, Dual and Diesel cycles is

(A) $\eta_{otto} > \eta_{Dual} > \eta_{Diesel}$
(B) $\eta_{Diesel} > \eta_{Dual} > \eta_{otto}$
(C) $\eta_{Dual} > \eta_{Diesel} > \eta_{otto}$
(D) $\eta_{Diesel} > \eta_{Otto} > \eta_{Dual}$

Answer: (B)

Exp: For same values of peak pressure and temperature. Diesel cycle is most efficient and Otto cycle is least. Efficiency of dual cycle lies in between.

$\eta_{diesel} > \eta_{dual} > \eta_{otto}$

51. During a TIG welding process, the are current and are voltage were 50 A and 60 V, respectively, when in the welding speed was 150 mm/mi. In another process, the TIG welding is carried out at a welding speed of 120 mm/min at the same arc voltage and heat input to the material so that weld quality remains the same. The welding current (in A) for this process is

(A) 40.00 (B) 44.72 (C) 55.90 (D) 62.25

Answer: (A)

Exp: Total heat input = VIt

time t is inversely proportional to weld speed (S)

$$\therefore \frac{V_2 I_2}{S_2} = \frac{V_1 I_1}{S_1}$$

$$\therefore I_2 = \frac{120}{150} \times 50$$

$$I_2 = 40\,A$$

52. Consider the following differential equation:

$$\frac{dy}{dt} = -5y;\ \text{initial condition : } y = 2 \text{ at } t = 0.$$

The value of y at t = 3 is

(A) $-5e^{-10}$ (B) $2e^{-10}$ (C) $2e^{-15}$ (D) $-15e^{2}$

Answer: (C)

Exp: $\frac{dy}{dt} = -5y$

$$\Rightarrow \frac{dy}{y} = -5dt\,(\text{variables separable form})$$

Integrating,

$\ln y = -5t + c$ ______ (1)

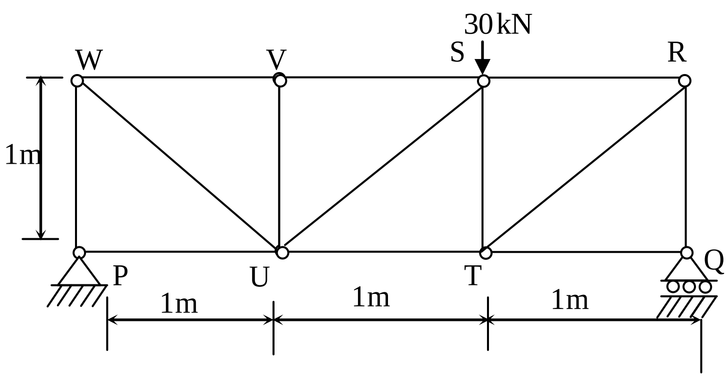
when $y = 2$ at $t = 0$ (initial conditional, (1) gives)

$c = \ln 2$

$$\therefore \ln y = -5t + \ln 2 \Rightarrow \ln\left(\frac{y}{2}\right) = -5t \Rightarrow y = 2e^{-5t}$$

at $t = 3, y = 2e^{-15}$

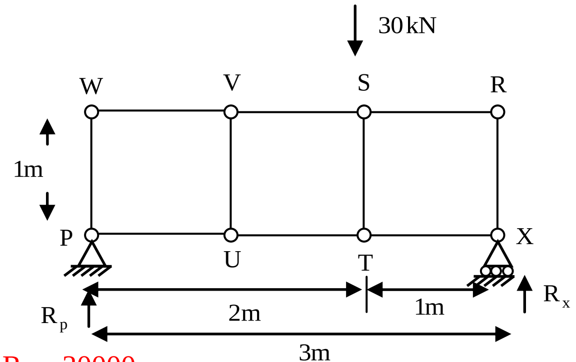
53. For the truss shown in the figure, the magnitude of the force (in kN) in the member SR is



(A) 10 (B) 14.14 (C) 20 (D) 28.28

Answer: (C)

Exp:



$R_p + R_x = 30000$

$\Sigma M_p = 0$

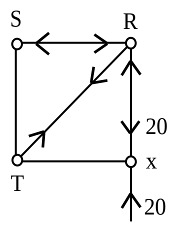
$R_x \times 3 = 2 \times 3000$

$\Rightarrow R_x = 20kN$

and $R_p = 10$ kN

for balance at 'x' $\rightarrow F_{Rx} = 20kN$

at 'RT' $\rightarrow F_{RT}\cos 45 = 20$



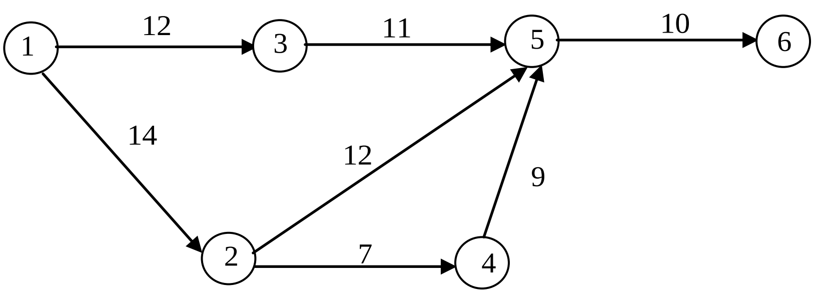
$\Rightarrow \Rightarrow F_{RT} = \dfrac{20}{\cos 45}$ _____ (1)

Also $F_{SR} = F_{RT}\cos 45$ _____ (2)

from (1) and (2)

$F_{SR} = 20$ kN

54. A project consists of 7 activities. The network along with the time durations (in days) for various activities is shown in the figure.



The minimum time (in days) for completion of the project is _____

Answer: 40

Exp: Time taken for 3 paths are as follows

Path 1 = 12+11+10

Path 2 = 14+12+10

Path 3 = 14+7+9+10

$\therefore$ Path3 is longest i.e. path 3 is critical path

$\therefore$ Project duration = 40 days

55. A resistance-capacitance relaxation circuit is used in an electrical discharge machining process. The discharge voltage is 100 V. At a spark cycle time of $\mu s,$ the average power input required is 1 kW. The capacitance $(\text{in } \mu F)$ in the circuit is

(A) 2.5 (B) 5.0 (C) 7.5 (D) 10.0

Answer: (A)

Exp: Voltage = 100V

Power = 1kW

$$\text{Power} = \frac{V^2}{R} \Rightarrow R = \frac{100 \times 100}{1000} = 10\Omega$$

$$\tau = RC \Rightarrow c = \frac{\tau}{R} = \frac{25}{10} = 2.5\mu F$$