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:
   A, CD, GHI, MNOP, UVWXY
   B +1 E,F +2 JKL +3 QRST +4

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 spirituality.

5. If x>y>1, 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)
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

\[0.9 \times \pi \times 30 \times 30 = \pi \times r^2 \times 30\]

\[\Rightarrow 27 \text{ cm} = r\]

\[\therefore \text{Height of the cone} = \sqrt{30^2 - 27^2}\]

\[= 13.08 \text{ cm}\]

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 21/05/2014, 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. \(\log \tan 1^\circ + \log \tan 2^\circ + \ldots + \log \tan 89^\circ\) is .......

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

Answer: (C)
Exp: \[ \log \tan 1^\circ + \log \tan 89^\circ = \log (\tan 1^\circ \times \tan 89^\circ) \]
\[ = \log (\tan 1^\circ \times \cot 1^\circ) \]
\[ = \log 1 \]
\[ = 0 \]
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 \( \sigma_y \),

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 \( \tau \) 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 \( V(x,y,z) = 2x^2i + 3z^2j + y^3k \) at \( x = y = z = 1 \) is

(A) \(-3i\) \hspace{1cm} (B) \(3i\) \hspace{1cm} (C) \(3i - 4j\) \hspace{1cm} (D) \(3i - 6k\)

Answer: (A)

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

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

\[= (3y^2 - 6z)i \bigg|_{x=y=z=1}\]

\[= -3i\]

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

\[m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2 \quad \text{(1)} \quad \text{moment conservation}\]

\(m_1 = 1 \text{ kg}, \quad u_1 = 12 \text{ m/s}\)

\(m_2 = 2 \text{ kg}, \quad u_2 = 0 \text{ m/s}\)

\[\frac{1}{2}m_1u_1^2 + \frac{1}{2}m_2u_2^2 = \frac{1}{2}m_1v_1^2 + \frac{1}{2}m_2v_2^2 \quad \text{(2)} \quad \text{energy conservation}\]

From (1) equation

\[12 = v_1 + 2v_2 \quad \text{(3)}\]

From (2) equation

\[\frac{1}{2} \times 1 \times 144 + \frac{1}{2} \times 2 \times 0 = \frac{1}{2} \times 1 \times v_1^2 + \frac{1}{2} \times 2 \times v_2^2\]

\[\Rightarrow 144 = v_1^2 + 2v_2^2 \quad \text{(4)}\]

From (3) and (4)

\[144 = 144 + 4v_2^2 - 48v_2 + 2v_2^2\]

\[\Rightarrow 6v_2^2 - 48v_2 = 0\]

\[6v_2(v_2 - 8) = 0\]

\[\Rightarrow v_2 = 8 \text{ m/s}\]
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
\[ \Rightarrow E = \frac{200 \text{MPa}}{0.003} = 200 \times 10^3 \text{MPa} \]
\[ = 200 \text{GPa} \]
\[
G = \frac{200}{2(1+0.3)} = \frac{200}{2 \times 1.3} = \frac{100}{1.3} = \frac{1000}{13} = 77 \text{GPa}
\]

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
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:

<table>
<thead>
<tr>
<th>Month</th>
<th>January</th>
<th>February</th>
<th>March</th>
<th>April</th>
<th>May</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of units sold</td>
<td>10</td>
<td>11</td>
<td>16</td>
<td>19</td>
<td>25</td>
</tr>
</tbody>
</table>

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 \( p + \frac{a}{v^2} (v - b) = RT \), 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^3/kg \(-s^2\)  (D) Pa/kg

Answer: (C)
Answer: (C)

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

\[
\Rightarrow \frac{N}{m^2} = \left( \frac{kg}{m^2} \right)^2
\]

\[
\Rightarrow a(\text{unit}) = \frac{m^6}{kg^2 \cdot \text{kg} \cdot s^2 \cdot \text{m}^2} = \frac{m^6 \cdot \text{kg} \cdot \text{kg} \cdot s^2}{\text{kg} \cdot s^2} = \frac{m^5}{\text{kg} \cdot s^2}
\]

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

Answer: 0.4

Exp:
\[
\omega_{nl} = \frac{C_{Cl}}{2m_i}
\]

\[
C_{Cl} = 2 \sqrt{K_1 m_i} = 2 \sqrt{Km}
\]

\[
C_{C2} = 2 \sqrt{K_2 m_2} = 2 \sqrt{8K \times 2m} = 4C_{Cl} = 4 \times 0.1 = 0.4
\]

15. The COP of a cannot heat pump operating between 6\( ^\circ \)C and 37\( ^\circ \)C is \___________

Answer: 10

Exp:
\[
(COP)_{\text{c,p}} = \frac{T_1}{T_1 - T_2} = \frac{310}{31} = 10
\]
16. The number of degrees of freedom of the planetary gear train shown in the figure is

![Planetary Gear Train Illustration]

(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: \[ P = T \omega \]
\[ T = \frac{10000}{400} = 25 \text{ N-m} \]

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 $e^{5t}$ where $i=\sqrt{-1}$, is

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

   Answer: (B)

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

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: $\sigma_1 = \frac{pd}{2t} = \frac{2 \times 14}{2 \times 0.05} = 280$MPa
       $\sigma_2 = \frac{pd}{4t} = \frac{2 \times 14}{4 \times 0.05} = 140$MPa
       $\sigma_3 = 0$

       Maximum shear stress = Maximum $\left\{\frac{\sigma_1 - \sigma_2}{2}, \frac{\sigma_2 - \sigma_3}{2}, \frac{\sigma_3 - \sigma_1}{2}\right\} = 140$MPa
24. In the laminar flow of air (Pr = 0.7) over a heated plate if \( \delta \) and \( \delta_t \) denote, respectively, the hydrodynamic and thermal boundary layer thicknesses, then

\[ \begin{align*}
(A) \quad & \delta = \delta_t \\
(B) \quad & \delta > \delta_t \\
(C) \quad & \delta < \delta_t \\
(D) \quad & \delta = 0 \text{ but } \delta_t \neq 0
\end{align*} \]

**Answer:** (C)

**Exp:**

When \( Pr < 1 \), \( \delta_t > \delta \)

When \( Pr > 1 \), \( \delta_t < \delta \)

When \( Pr = 1 \), \( \delta_t = \delta \)

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.  
\( \therefore \) 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 \( \propto T_1^4 \)

\( 500 \propto T_1^4 \) \( \text{____}(1) \)

or

\( 500 = k T_1^4 \) \( \text{____}(1) \)

similarly

\( 1200 = k T_2^4 \) \( \text{____}(2) \)

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 hollow 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°. 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:
\[ P = T \omega \]
\[ 30 \times 1000 = T \times \frac{2\pi \times 700}{60} \]
\[ \therefore T = 409.256 \text{ N} - \text{m} \]
\[ \frac{T}{I_p} = \frac{G\theta}{l} \]
\[ \frac{409.256}{\frac{\pi}{32}(1 - 0.7^4)d_0^4} = \frac{80 \times 10^9}{1} \times \frac{\pi}{180} \left( l = 1 \text{ m} \right) \]
Solving, we get
\[ d_0 = 44.5213 \text{ mm} \]

28. In a Rankine cycle, the enthalpies at turbine entry and outlet are 3159 kJ/kg and 2187 kJ/kg,
respectively. If the specific pump work is 2 kJ/kg the specific steam consumption (in kg/kW-h)
of the cycle based on net output is _______
Answer: 3.71

Exp:
Specific steam consumption
\[ \frac{W_T - W_P}{3600} \]
\[ W_T = h_2 - h_1 = 3159 - 2187 = 972 \text{ kJ/kg} \]
\[ W_P = 2 \text{ kJ/kg} \]
Thus specific steam consumption
\[ = \frac{3600}{972 - 2} \text{ kg/kW-h} \]
\[ = 3.71 \text{ kg/kW-h} \]

29. A single point cutting tool with 0° rake angle is used in an orthogonal machining process. At
a cutting speed of 180 m/min, the thrust force is 490 N. 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:
\[ \mu = \frac{F}{N} = \frac{F_c \sin \alpha + F_r \cos \alpha}{F_c \cos \alpha - F_r \sin \alpha} \]
Given: \( \alpha = 0^\circ \)
\[ \therefore \mu = \frac{F_r}{F_c} \]
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 $A \rightarrow$ student passes the exam  
$B \rightarrow$ student gets above 90% marks  
Given $P(A) = 20\%$; $P(A \cap B) = 5\%$

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 $h \propto \frac{u_{avg}}{D^2}$
\[ \therefore \frac{h_2}{h_1} = \left( \frac{D_1}{D_2} \right)^2 \frac{u_{\text{avg.} 2}}{u_{\text{avg.} 1}} = 2^2 \times 2 \]

\[ \frac{h_2}{h_1} = 8 \]

33. A cube and a sphere made of cast 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:**

solidification time = \( k \left( \frac{V}{A} \right)^2 \)

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

\( k \frac{a^2}{36} = 4 \)

\( k a^2 = 36 \times 4 \quad (1) \)

vol. of cube = vol. of sphere

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

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

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

\[ \Rightarrow k \left( \frac{3}{4\pi} \right)^{1/3} \cdot \frac{a}{3} \]

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

= 6.1573sec

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

**Answer:** -116.36
Exp: \[ s_2 - s_1 = mR \ln \frac{V_2}{V_1} \]

\[ = 287 \ln \frac{0.6}{0.9} = -116.368 \text{J/kgK} \]

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

(A) 20 \hspace{1cm} (B) 25 \hspace{1cm} (C) 50 \hspace{1cm} (D) 100

Answer: \( \text{(C)} \)

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

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

\[ = 50 \text{ MPa} \]

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. \( C_v = 100 \text{J/(kg.K)} \) 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

\[ m \left[ \frac{V_1^2 - V_2^2}{2} \right]^2 + (z_1 - z_2)g + (h_1 - h_2) = W \]

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

\[ W = -4.5 \text{kJ} \]

\[ \therefore \text{Work done on the system is 4.5 kJ.} \]

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 \hspace{1cm} (B) 22.58 mm \hspace{1cm} (C) 33.87 mm \hspace{1cm} (D) 45.16 mm

Answer: \( \text{(B)} \)

Exp: \[ P = T \omega \]
\[ 20 \times 10^3 = T \times \frac{2 \pi \times 3000}{60} \]
\[ \therefore T = 63.662 \text{ N} \cdot \text{m} \]
\[ \frac{T}{I_p} = \frac{\tau}{r}, \]
\[ \frac{63.662}{\pi (15d^4)} = \frac{30 \times 10^6}{d_1} (r_0 = d), \]
\[ \therefore d_1 = 11.295 \text{ mm} \]
\[ \therefore d_0 = 2d_1 = 22.59 \text{ mm} \]

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 \( \text{...} \)

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

Answer: (C)

Exp:
\[ M = 5 \times 2 = 10 \text{ kN} \]
39. The flow stress (in MPa) of a material is given by

\[ \sigma = 500 \varepsilon^{0.1} \]

Where \( \varepsilon \) 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:**

True strain = \( \ln \frac{100}{95} = 0.5129 \)

\[ \sigma = 500 \times (0.5129)^{0.1} \Rightarrow 371.5147523 \]

Upto elastic limits using hook’s law

\[ E = \frac{\sigma \times l}{\Delta l} \]

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

\[ \Rightarrow \Delta l = \frac{0.18575}{\text{mm}} \text{ – considering this for elastic recovery} \]

\[ \therefore \text{This will be added to 95 mm} \]

\[ \Rightarrow \text{Final dimension} = 95.18575 \text{ mm} \]

40. The initial velocity of an object is 40 m/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:**

\[ a = -0.1V \]

\[ \frac{dv}{dt} = -0.1V \]

\[ \ln v = -0.1t + \ln k \]

\[ V = ke^{-0.1t} \]

at \( t = 0 ; V = 40 \)

\[ \therefore k = 40 \]

\[ V = 40e^{-0.1t} \]

at \( t = 3 \text{ seconds} \)

\[ V = 40 \times e^{-0.1 	imes 3} = 29.6327 \text{ m/s} \]

41. A balanced counter flow heat exchanger has a surface area of 20 m\(^2\) and overall heat transfer coefficient of 20 W/m\(^2\) – K. Air (\( \rho = 1000\text{J/kg – K} \)) 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 $A = 20 \text{m}^2$

Mass flowrate $0.4 \text{kg/s}$

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

Temperature $T_{i} = 280 \text{K}$

$T_{co} = ?$

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

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

Assume $C_{p}$ is same $= 1000 \frac{\text{J}}{\text{kg.K}}$

Hence

\[ \Delta T_{i} = T_{i} - T_{ci} = \Delta T_{2} = T_{hi} - T_{ci} \]

\[ \Delta T_{i} = 300 - T_{co} = T_{ho} - 280 \]

\[ \Delta T_{m} = \Delta T_{1} = \Delta T_{2} \]

\[ uA\Delta T_{m} = mC_{p}(T_{ho} - T_{ci}) \]

\[ 20 \times 20 \times (300 - T_{ci}) = 0.4 \times 1000(T_{co} - 280) \]

\[ 2T_{co} = 300 + 280 \]

\[ T_{co} = \frac{580}{2} = 290 \text{K} \]

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

<table>
<thead>
<tr>
<th>$x$</th>
<th>0</th>
<th>0.1</th>
<th>0.2</th>
<th>0.3</th>
<th>0.4</th>
</tr>
</thead>
<tbody>
<tr>
<td>$f(x)$</td>
<td>0</td>
<td>10</td>
<td>40</td>
<td>90</td>
<td>160</td>
</tr>
</tbody>
</table>

Using Trapezoidal rule with step size of 0.1, the value of $\int_{0}^{0.4} f(x) \, dx$ is ________

**Answer:** 22

<table>
<thead>
<tr>
<th>$x$</th>
<th>0</th>
<th>0.1</th>
<th>0.2</th>
<th>0.3</th>
<th>0.4</th>
</tr>
</thead>
<tbody>
<tr>
<td>$y = f(x)$</td>
<td>0</td>
<td>10</td>
<td>40</td>
<td>90</td>
<td>160</td>
</tr>
</tbody>
</table>

| $y_0$ | $y_1$ | $y_2$ | $y_3$ | $y_4$ |

† India’s No.1 institute for GATE Training † 1 Lakh+ Students trained till date † 65+ Centers cross India
\[ \int_0^{0.4} f(x) \, dx = \int_0^{0.4} y \, dx = \frac{h}{2} \left[ (y_0 + y_4) + 2(y_1 + y_2 + y_3) \right] \]
\[ = \frac{0.1}{2} \left[ (0 + 160) + 2(10 + 40 + 90) \right] \]
\[ = 22 \]

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 than 0.3. (A) is the correct answer, as overall reduction will be less than 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 \( \omega \) 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 10\( \omega \). 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
\[ A = \sqrt{\frac{f_0}{\omega^2}} \]
\[ = \sqrt{\frac{10/150}{\left[1 - \left(\frac{1}{10}\right)^2\right] + \left(2 \times 0.2 \times \frac{1}{10}\right)^2}} \]
\[ = 0.06605 \approx 0.07 \]

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 \( \Delta P = 10\)Pa/m. The magnitude of axial velocity (in m/s) at a radial location of 0.2 cm is \( \square \)

**Answer:** 6.24

**Exp:**
\[ G = \frac{-1}{4\mu} \frac{\partial P}{\partial x} \left( R^2 - r^2 \right) \]
\[ = \frac{-1}{4 \times 0.001} \times (-10) \left( (0.05)^2 - (0.002)^2 \right) \]
46. In a certain slider-crank mechanism, lengths of crank and connecting rod are equal. If the crank rotates with a uniform angular speed of 14 rad/s and the crank length is 300 mm, the maximum acceleration of the slider (in m/s²) is ___________

Answer: 117.6

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

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

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

47. The surface integral $\int \int \frac{1}{\pi} (9x \hat{i} - 3y) \cdot \hat{n} dS$ over the sphere given by $x^2 + y^2 + z^2 = 9$ is ____

Answer: 216

Exp: By Gauss divergence theorem,

$$\int \int \int \text{div} \bar{F} dV = \int \int \bar{F} \cdot \hat{n} ds$$

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

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

$$\therefore \int \int \frac{1}{\pi} (9x \hat{i} - 3y \hat{j}) \cdot \hat{n} ds = \frac{1}{\pi} \int \int 6 dV = \frac{1}{\pi} 6V$$

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

$$= 8(3)^3$$

$$= 216.$$
\[ \theta = \frac{-2000(0.02)}{2 \times 210 \times 10^9 \times (0.006)^2} (2 \times 0.1 - 0.02) \]
\[ = -0.1587 \]

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 \(4 \times 10^7 \text{ W/m}^3\). The rod is cooled by a liquid (convective heat transfer coefficient 1000 \(\text{W/m}^2\cdot\text{K}\)) at 25°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. \(T_s = T_a + \frac{\dot{q}_w}{2h} R\)
\[ = 298 + \frac{4 \times 10^7}{2 \times 1000} \times 5 \times 10^{-3} \]
\[ T_s = 398 \text{ K} \]

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) \(\eta_{\text{otto}} > \eta_{\text{dual}} > \eta_{\text{Diesel}}\)  
(B) \(\eta_{\text{Diesel}} > \eta_{\text{dual}} > \eta_{\text{otto}}\)  
(C) \(\eta_{\text{dual}} > \eta_{\text{Diesel}} > \eta_{\text{otto}}\)  
(D) \(\eta_{\text{Diesel}} > \eta_{\text{otto}} > \eta_{\text{dual}}\)

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.
\(\eta_{\text{Diesel}} > \eta_{\text{dual}} > \eta_{\text{otto}}\)

51. During a TIG welding process, the arc 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)
52. Consider the following differential equation:
\[
\frac{\text{dy}}{\text{dt}} = -5y; \text{ initial condition : } y=2 \text{ at } t=0.
\]
The value of \( y \) at \( t = 3 \) is
(A) \(-5e^{-10}\)  (B) \(2e^{-10}\)  (C) \(2e^{-15}\)  (D) \(-15e^2\)
Answer: (C)
Exp:
\[
\frac{\text{dy}}{\text{dt}} = -5y
\]
\[\Rightarrow \frac{\text{dy}}{y} = -5\text{dt} \quad \text{(variables separable form)}\]
Integrating,
\[\ln y = -5t + c \quad \text{(1)}\]
when \( y = 2 \) at \( t = 0 \) (initial condition, (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
![Truss Diagram]
(A) 10  (B) 14.14  (C) 20  (D) 28.28
Answer: (C)
Exp:

\[ R_p + R_x = 30000 \]
\[ \Sigma M_p = 0 \]
\[ R_x \times 3 = 2 \times 3000 \]
\[ \Rightarrow R_x = 20 \text{kN} \]
\[ \text{and } R_p = 10 \text{kN} \]

for balance at ‘x’ \( \Rightarrow F_{Rx} = 20 \text{kN} \)

at ‘RT’ \( \Rightarrow F_{RT} \cos 45 = 20 \)

\[ \Rightarrow \Rightarrow F_{RT} = \frac{20}{\cos 45} \quad (1) \]

Also \( F_{SR} = F_{Rx} \cos 45 \quad (2) \)

from (1) and (2)
\[ F_{SR} = 20 \text{kN} \]

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
\[ \therefore \text{Path 3 is longest i.e. path 3 is critical path} \]
\[ \therefore \text{Project duration} = 40 \text{ days} \]

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 \( \mu \text{s} \), the average power input required is 1 kW. The capacitance (in \( \mu \text{F} \)) in the circuit is

\[
\begin{align*}
(A) & \quad 2.5 \\
(B) & \quad 5.0 \\
(C) & \quad 7.5 \\
(D) & \quad 10.0
\end{align*}
\]

**Answer:** (A)

**Exp:**

Voltage = 100V

Power = 1kW

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

\[
\tau = RC \Rightarrow C = \frac{\tau}{R} = \frac{25}{10} = 2.5\mu\text{F}
\]