Sample paper 4

Question 1

Which of the following is a dimensionally correct representation for angular momentum?

A. $M^2L^2T^{-1}$
B. $M^2L^1T^{-1}$
C. $M^2L^1T^{-2}$
D. ML^2T^{-1}
E. ML^1T^{-1}

Correct Answer: D

Explanation:

Angular momentum is given as
$L = I\omega$ ------------ (1)
SI unit for I is kgm^2. Hence, dimensional formula of I becomes ML^2. Angular velocity is given as
$\omega = v/r$
SI unit of v is m/s and that of r is m. Hence, SI unit of angular velocity becomes
(m/s)/m Or 1/s
Therefore, dimensional formula of angular velocity is T^{-1} . Thus, dimensional formula of angular momentum from equation 1 becomes
ML^2 / T Or ML^2T^{-1}
Hence, D is the correct answer option.

Question 2

A train at rest starts from station A and travels to station B at a distance of 2 km in 4 minutes? Consider the following statements.

Instantaneous speed of the train is 8.33 m/s

Average speed of the train is 8.33 m/s

Instantaneous acceleration of the train is 8.33 m/s²

A. **Which of the following statement(s) is/are true?**
B. 1
C. 2
D. 3
E. Both 1 and 3
F. Both 2 and 3

Correct Answer: B

Explanation:

Instantaneous speed of a body is the speed possessed by it at any particular time instant. Instantaneous speed is a variable and changes accordingly. Speedometer is a device that is used by the vehicles to know the speed possessed by it at that instant. Average velocity or speed provides speed of the body for the full journey. It is given as the total distance travelled in total time taken. As in the question the total time and the total distance are given, hence average speed can be found as

Average speed = Total Distance / Total Time ------------- (1)

Since, distance and time are given in kilometers and minutes we need to convert them Putting the values in equation 1 we get

Average speed = 8.33 m/s

Instantaneous acceleration is related to instantaneous speed. Hence, instantaneous acceleration cannot be found here. Thus, B is the correct answer option.

Question 3

A water gallon of mass 500 kg is resting on a horizontal floor. What would be its normal reaction?

A. 500 N
B. 4900 N
C. 5100 N
D. 250 N
E. 51.02 N

Correct Answer: B

Explanation:

As the water gallon is resting on the floor, normal reaction will be balanced by the weight of the gallon itself. Therefore,
Normal reaction = Weight of the gallon ------------- (1)
Weight of the gallon is given as
F = mg------------- (2)
Putting the values in equation 1 we get
F = 500 * 9.8 Or F = 4900 N
Using equation 1 we get
Normal reaction = 4900 N
Therefore, B is the correct answer option.

Question 4

A boy of 45 kg jumps out of a window and just before reaching the ground his speed is 2 m/s. After he hits the ground he stops and the total time taken during this process is 1 s. What is the force exerted by the ground on the boy?

A. 45 N
B. 22.5 N
C. 180 N
D. 90 N
E. 85 N

Correct Answer: D

Explanation:

According toNewton's second law of motion, force is time rate of change of momentum and is given as
F = p / t ------------ (1)
Momentum is given as

$p = mv$ ------------- (2)
Putting the value of m and v in equation 2 we get $p = 45 * 2$ Or $p = 90$ kgm/s
Putting the values of p and t in equation 1 we get
$F = 90$ N
Therefore, D is the correct answer option.

Question 5

A flying disc initially at rest rotates with a constant acceleration. If after 5 s the flying disc has rotated by 200 radians, what is its angular acceleration?

A. 14 rad/s^2
B. 15 rad/s^2
C. 11 rad/s^2
D. 12 rad/s^2
E. 16 rad/s^2

Correct Answer: E

Explanation:

Here we will apply theequation of rotational motion, which is given as

$\theta = \omega_i t + (1/2)\alpha t^2$ -------------- (1)
Putting the values in equation 1 we get

$200 = 0 * t + (1/2)\ \alpha 5^2$
$\alpha = 400/25$
Or $\alpha = 16$ rad/s^2
Therefore, E is the correct answer option.

Question 6

What would be the efficiency of a motor, if its input power is 500 Joules and the output power is 100 Joules?

A. 18%
B. 15%
C. 20%
D. 10%
E. 21%

Correct Answer: C

Explanation:

Efficiency of a motor is given as

$\% \eta = \{P_{output} / P_{input}] * 100$ -------------- (1)

Putting the values in equation 1, we get
$\% \eta = [100 / 500] * 100$
Or, $\% \eta = 20\%$
Hence, C is the correct answer option.

Question 7

A body of mass 0.3 kg connected to a spring having a spring constant of 20 N/m is executing SHM. What is the time period of the SHM?

A. 0.65 s
B. 0.56 s
C. 0.75 s
D. 0.87 s
E. 0.14 s

Correct Answer: C

Explanation:

Time period is given as

$T = 2\pi \sqrt{m / k}$ -------------- (1)

Putting the values in equation 1 we get $T = 2\pi \sqrt{0.3 / 20}$

Or, $T = 2 * 3.14 * 0.12$ ($\pi = 3.14$)
$T = 0.75$ s
Therefore, C is the correct answer option.

Question 8

Two trains A and B approach a station at 10 m/s and 20 m/s respectively. A stationary observer in the station can hear the sound of the whistle produced by A only. If the original frequency of the whistle blown by train A is 300 Hz, what would be the apparent frequency of the sound of the whistle heard by the observer? (Assume speed of sound in air = 340 m/s)

A. 300 Hz
B. 291.42 Hz
C. 283.33 Hz
D. 318.75 Hz
E. 309.09 Hz

Correct Answer: E

Explanation:

This question can be solved by applying Doppler's effect for sound waves. Doppler's effect is related to change in original frequency of sound if either the source or the observer is moving simultaneously.
Doppler's effect is given as
$f = [(v - v_r) / (v - v_s)]f_o$ -------------- (1)
Putting the values in equation 1 we get f = [(340) / (340-10]*300
f = (34/33)*300
Or f = 309.09 Hz
Therefore, E is the correct answer option.

Question 9

A body in a cubical shape of dimension and having mass of 2 kg is fully immersed in a fluid. What is the specific gravity of the body?

A. 0.357
B. 0.453
C. 0.564
D. 0.181
E. 0.097

Correct Answer: A

Explanation:

Density is given as
$\rho = m/V$ ------------- (1)

Volume of the body is given as
$V = 0.7 * 0.1 * 0.08$ Or $V = 5.6 \times 10^{-3} m^3$
Putting the values in equation 1 we get
$\rho = 2 / 5.6 \times 10^{-3}$
Or $\rho = 357.14 \ kg/m^3$
Specific gravity is given as

$SG = \rho_{body} / \rho_{water}$ ---------------- (2)
Putting the values in equation 2 we get
$SG = 357.14 / 1000$ Or $SG = 0.357$
Therefore, A is the correct answer option.

Question 10

A heat engine performs work of 10000 J while transferring heat of 12000 J. What is the efficiency of the engine?

A. 83.3 %
B. 84.5 %
C. 78.6 %
D. 45.7 %
E. 41.6 %

Correct Answer: A

Explanation:

Efficiency of a heat engine is given as

$\eta = W / Q$ --------------- (1)

Putting the values in equation 1 we get
$\%\eta = 10000 / 12000$
$\%\eta = 0.833 \times 100\%$
Or $\%\eta = 83.3$ %
Therefore, A is the correct answer option.

Question 11

Two charged particles of charges 4 nC and – 4 nC are kept 0.2 m cm apart. What is the magnitude and nature of the electrostatic force? (Permittivity of free space = 8.85 x 10^{-12} F/m)

A. -3.6 x 10^{-6} N and attractive
B. -2.7 x 10^{-6} N and attractive
C. -6.7 x 10^{-6} N and attractive
D. -4.5 x 10^{-7} N and repulsive
E. 4.5 x 10^{-7} N and attractive

Correct Answer: A

Explanation:

Electrostatic force in a region is given as

F = [(1 / 4$\pi\varepsilon_o$) (q_1q_2 / R)] -------------- (1)

Standard value of 1 / 4$\pi\varepsilon_o$ is 9 x 10^9 Nm^2C^{-2}
We are given values of charges in nC so we need to convert them into C.
1 nC = 10^{-9}C or -4 nC = - 4x10^{-9} C
Putting the values in equation 1 we get
F = 9 x 10^9 x [(4 x 10^{-9} * 4 x 10^{-9}) / 0.2^2]
Or F = -3.6 x 10^{-6} N
As force is negative, that suggests nature of force is attractive.
Hence, A is the correct answer option.

Question 12

What is the current density of electrons flowing through a steel block of length 1 m, if potential difference applied across the conductor is 200 V? (Conductivity of steel = 1.45 x 10^6 $\Omega^{-1}m^{-1}$)

A. 2.9 x 10^8 A/m^2
B. 1.4 x 10^8 A/m^2
C. 2.2 x 10^8 A/m^2
D. 3.4 x 10^9 A/m^2
E. 1.45 x 10^4 A/m^2

Correct Answer: A

Explanation:

Current density is given as

J = σE -------------- (1)

Electric field is given as

E = V / l --------------- (2)

Putting the values in equation 2 we get

E = 200/1 Or E = 200 v/m
Putting the values in equation 1 we get

$J = 1.45 \times 10^6 \times 200$
Or $J = 2.9 \times 10^8\ Am^2$

Hence, A is the correct answer option.

Question 13

A solenoid of length 60 cm and radius 2.4 cm carries current of 3 A. If the number of turns is 400, what is the magnetic field at the center of the solenoid on its axis? (Permeability of free space is $4\pi \times 10^{-7}$ $WbA^{-1}m^{-1}$)

A. 2.5×10^{-3} T
B. 1.5×10^{-3} T
C. 4.5×10^{-4} T
D. 5.2×10^{-4} T
E. 1.8×10^{-4} T

Correct Answer: A

Explanation:

Magnetic field at the center of a solenoid is given as

$B = (\mu_o nI) / l$ ------------- (1)

As length is given in cm we need to convert it into m.
1 cm = 10^{-2} m
60 cm = 0.6 m
Putting the values in equation 1 we get
$B = [(4\pi \times 10^{-7} * 400 * 3) / 0.6]$
($\pi = 3.14$)
$B = 2.5 \times 10^{-3}$ T
Hence, A is the correct answer option.

Question 14

What would be the minimum angle of incidence so that a ray of light travelling from medium 1 of refractive index 1.7 to medium 2 of refractive index 1.5 does not emerge out of medium 2?

A. $\sin^{-1}(0.88)$
B. $\cos^{-1}(0.88)$
C. $\tan^{-1}(0.88)$
D. $\tan^{-1}(1.13)$
E. $\sin^{-1}(1.13)$

Correct Answer: A

Explanation:

For a ray of light incident on a medium to not emerge from it is known as limiting case of total internal reflection. For the minimum angle the refracted ray travels along the interface. For the incident ray making an angle more than the minimum angle the ray will reflect back and this is known as total internal reflection. From Snell's law we have

$\mu_1 \sin \theta_i = \mu_2 \sin \theta_r$ ---------------- (1)

Putting the values in equation 1 we get
1.7 sin θ_i = 1.5 * sin 90^o
$\theta_i = \sin^{-1}(0.88)$
Therefore, A is the correct answer option.

Question 15

A photon of frequency 350 GHz is incident on a metal surface. What is the energy of the photon in eV? (Planck's constant = 6.6×10^{-34} Js)

A. 2.34×10^{-3} eV
B. 1.24×10^{-2} eV
C. 1.44×10^{-3} eV
D. 3.46×10^{-2} eV
E. 0.45 eV

Correct Answer: C

Explanation:

Energy possessed by a photon is given as

E = hv --------------- (1)

Frequency is given in GHz so, we need to convert it into Hz.
1 GHz = 10^9Hz
350 GHz = 3.5×10^{11} Hz
Putting the values in equation 1 we get
E = $6.6 \times 10^{-34} * 3.5 * 10^{11}$
Or E = 2.31×10^{-22} J
We need to convert energy in Joules into eV as given below
1.6×10^{-19} J = 1 eV
1 J = 1 / (1.6×10^{-19}) eV
Or 2.31×10^{-22} J = 1.44×10^{-3} eV
Therefore, a photon with frequency of 350 GHz has energy of 1.44×10^{-3} eV. Hence, C is the correct answer option.