

Sample paper 7

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

$$L = I\omega \text{ ----- (1)}$$

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

$$(m/s)/m \text{ Or } 1/s$$

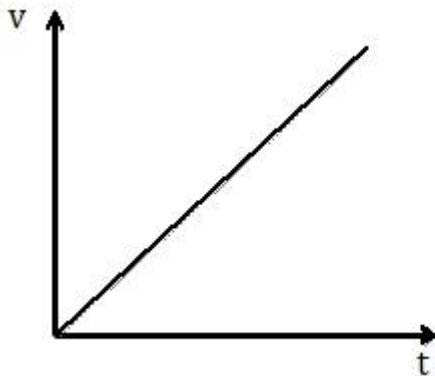
Therefore, dimensional formula of angular velocity is T^{-1} . Thus, dimensional formula of angular momentum from equation 1 becomes

$$ML^2 / T \text{ Or } ML^2T^{-1}$$

Hence, D is the correct answer option.

Question 2

Consider the figure and the statements given below.



(v is velocity and t is time)

1. The graph is for a body that is accelerating
2. The graph is for a body that is falling freely
3. The graph is for a body that has constant velocity

Which of the following statement(s) is true in accordance to the given figure?

- A. 2
- B. 1
- C. 3
- D. Both 1 and 2

Both 2 and 3

Correct Answer: A

Explanation:

The graph given in the question is between velocity and time. Slope of the velocity time graph is linear here. Therefore, velocity increases with each instant but change in velocity per unit time is constant throughout the travel. Thus, 3 is an incorrect statement and so is option C. Acceleration of a body is defined as the rate of change of velocity per unit time. As said earlier, for a linear slope between velocity and time, change in velocity is constant per unit time and thus, acceleration is constant for the entire travel. Therefore, statement 1 is incorrect and so is option B. A body falls freely under gravity only. A free falling body always experiences uniform acceleration throughout the travel. Thus, we can say that acceleration is constant for a free fall and the graph essentially represents the motion of free fall. Thus, statement 2 is correct and so A is the correct answer option. In view of the above discussion, options D and E are incorrect as well.

Question 3

If a block of wood weighs 1000 N, what would be its mass?

- A. 102.04 kg
- B. 10.24 kg
- C. 1020.44 kg
- D. 1.24 kg
- E. 110.24 kg

Correct Answer: A

Explanation:

Weight of a body is given as

$$W = mg \text{ ----- (1)}$$

Putting the value of W and g in equation 1 we get

$$1000 = m * 9.8$$

$$m = 102.04 \text{ kg}$$

Therefore, A is the correct answer option.

Question 4

Which of the following combinations of forces can lead to a resultant unbalanced force of 10 N, if both the forces are acting orthogonally?

- A. 4 N and 5 N
- B. 6 N and 8 N
- C. 5 N and 8 N
- D. 8 N and 8 N
- E. 5 N and 5 N

Correct Answer: B

Explanation:

Resultant force is given as

$$R = \sqrt{F_1^2 + F_2^2 + F_1 F_2 \cos\theta}$$

As both the forces are acting orthogonally, $\theta = 90^\circ$.

$$R = \sqrt{F_1^2 + F_2^2 + F_1 F_2 \cos 90^\circ}$$

$$\text{Or } R = \sqrt{F_1^2 + F_2^2 + F_1 F_2 \times 0}$$

$$\text{Or } R = \sqrt{F_1^2 + F_2^2}$$

If we take $F_1 = 6$ and $F_2 = 8$ N, we get

$$R = \sqrt{6^2 + 8^2}$$

$$\text{Or } R = 10 \text{ N}$$

Putting the values as mentioned in options A, C, D and E, we get the value of the resultant force as 6.4 N, 9.43 N, 11.3 N and 7.07 N. Hence B is the correct answer option.

Question 5

If a wheel is rotating with an angular velocity of 2.5 rad/s, what is the time taken by the wheel to complete one full rotation?

- A. 1.57 s
- B. 2.51 s
- C. 1.84 s
- D. 3.52 s
- E. 2.22 s

Correct Answer: B

Explanation:

Time taken to complete one rotation is known as time period. Angular velocity is related to time period as

$$\omega = \frac{2\pi}{T} \text{----- (1)}$$

Putting the values of ($\pi = 3.14$) and ω in equation 1 we get

$$2.5 = \frac{(2 \times 3.14)}{T}$$

$$T = 2.51 \text{ s}$$

Therefore, B is the correct answer option.

Question 6

An object is to be lifted from the ground to a height of 5m in 25 seconds. If the energy consumed during the process is 2000 J, what is the power required?

- A. 75 J/s
- B. 72 J/s
- C. 80 J/s
- D. 100 J/s
- E. 125 J/s

Correct Answer: C

Explanation:

Power is given as

$$P = W/t \text{ ----- (1)}$$

Putting the values in equation 1 we get

$$P = 2000 / 25$$

$$P = 80 \text{ J/s or Watt}$$

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

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

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

$$\text{Or, } T = 2 * 3.14 * 0.12 \text{ (}\pi = 3.14\text{)}$$

$$T = 0.75 \text{ s}$$

Therefore, C is the correct answer option.

Question 8

A radio FM is broadcasting signals at a frequency of 400 MHz. What is the wavelength of the signal, if it is travelling at a speed of 2.5×10^8 m/s ?

- A. 0.534 m
- B. 0.625 m
- C. 0.725 m
- D. 0.918 m
- E. 0.025 m

Correct Answer: B

Explanation:

Speed of the wave is given as

$$v = f \lambda \text{ ----- (1)}$$

As the frequency is given in MHz, we need to convert it into Hz.

$$1 \text{ MHz} = 10^6 \text{ Hz}$$

$$400 \text{ MHz} = 400 \times 10^6 \text{ Hz}$$

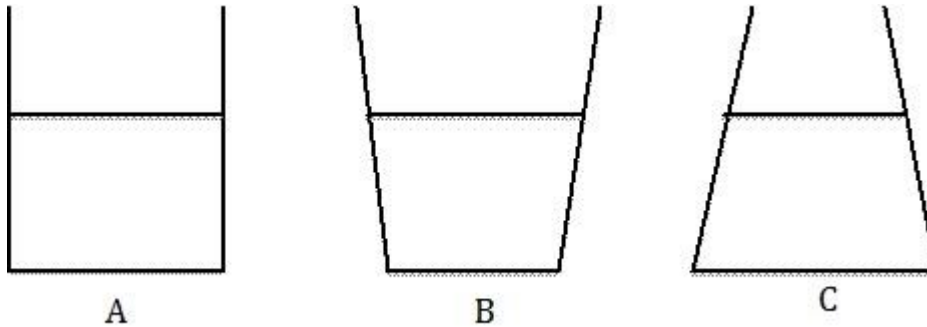
Putting the values in equation 1 we get

$$2.5 \times 10^8 = 400 \times 10^6 \times \lambda \text{ Or } \lambda = 0.625 \text{ m}$$

Therefore, wavelength of the FM signal is 0.625 m and thus, B is the correct answer option.

Question 9

Consider the figure given below.



Three vessels of different shapes are filled with water to the same height. Which of the following is a correct statement?

- A. Pressure at the bottom of A is more than that at the bottom of B
- B. Pressure at the bottom of B is more than that at the bottom of C
- C. Pressure at the bottom of C is more than that at the bottom of A
- D. All have the same volume
- E. All have the same pressure

Correct Answer: E

Explanation:

All three vessels A, B and C are of different shapes. So, fluids inside the vessels will also have different shapes. Due to different shapes, volumes of the fluids enclosed inside the vessels for the three different cases will be different as well. Hence, D is an incorrect option. Pressure at the bottom of a vessel due to the fluid it contains is given as

$$P = \rho gh$$

It can be concluded from the equation that pressure depends on density of the fluid and height to which a vessel is filled. Since, the fluid here is common for all the vessels and the height of the fluid is also the same; therefore, pressure exerted by the fluid at the bottom for all the vessels will be the same. Hence, E is the correct answer option.

Question 10

A sample of gas at 313 K occupies a volume of 10 m^3 . What would be its volume at 373 K?

- A. 11.92 m^3
- B. 15.56 m^3
- C. 10.45 m^3

- D. 12.67 m³
- E. Cannot be determined

Correct Answer: A

Explanation:

This question can be solved by applying Charles's law, which is given as

$$V_1 / T_1 = V_2 / T_2 \text{ ----- (1)}$$

Putting the values in equation 1 we get

$$10/313 = V_2/373$$

$$V_2 = 11.92 \text{ m}^3$$

Therefore, A is the correct answer option.

Question 11

A test charge of magnitude 6nC is kept on the positive x-axis. If it is experiencing a force of 2×10^{-6} along the positive direction of x-axis due to a charge kept on negative x-axis, what is the electric field and its nature?

- A. 333.33 N/C and positive
- B. 5.44.65 N/C and negative
- C. 622.45 N/C and positive
- D. 322.55 N/C and negative
- E. 372.23 N/C and positive

Correct Answer: A

Explanation:

Electrostatic force is given in terms of electric field as

$$F = q E \text{ ----- (1)}$$

We are given the values of charges in nC so we need to convert them into C.

$$1 \text{ nC} = 10^{-9} \text{ C}$$

$$6 \text{ nC} = 6 \times 10^{-9} \text{ C}$$

Putting the values in equation 1 we get

$$2 \times 10^{-6} = 6 \times 10^{-9} * E$$

$$E = 333.33 \text{ N/C}$$

Therefore, 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 = $1.45 \times 10^6 \Omega^{-1} \text{ m}^{-1}$)

- A. $2.9 \times 10^8 \text{ A/m}^2$
- B. $1.4 \times 10^8 \text{ A/m}^2$
- C. $2.2 \times 10^8 \text{ A/m}^2$
- D. $3.4 \times 10^9 \text{ A/m}^2$
- E. $1.45 \times 10^4 \text{ A/m}^2$

Correct Answer: A

Explanation:

Current density is given as

$$J = \sigma E \text{ ----- (1)}$$

Electric field is given as

$$E = V / l \text{ ----- (2)}$$

Putting the values in equation 2 we get

$$E = 200/1 \text{ Or } E = 200 \text{ v/m}$$

Putting the values in equation 1 we get

$$J = 1.45 \times 10^6 \times 200$$

$$\text{Or } J = 2.9 \times 10^8 \text{ Am}^2$$

Hence, A is the correct answer option.

Question 13

A beta particle of mass $9.1 \times 10^{-31} \text{ kg}$ is moving perpendicular to a magnetic field in a region of 0.01 T with a speed of 10^4 . What is the force experienced by the beta particle due to the magnetic field? (Charge on electron = $1.6 \times 10^{-19} \text{ C}$)

- A. $3.2 \times 10^{-17} \text{ N}$
- B. $1.6 \times 10^{-17} \text{ N}$
- C. $4.8 \times 10^{-17} \text{ N}$
- D. $2.4 \times 10^{-17} \text{ N}$
- E. 10^{-17} N

Correct Answer: B

Explanation:

Force experienced by the beta particle is given as

$$F = qnB \sin \theta \text{ ----- (1)}$$

As the beta particle is moving perpendicularly to the magnetic field, $\theta = 90^\circ$. Charge on a beta particle is equal to the charge on an electron;

$$F = 1.6 \times 10^{-19} \times 10^4 \times 0.01 \times \sin 90^\circ$$

$$F = 1.6 \times 10^{-17} \text{ N}$$

Hence, B 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

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

Putting the values in equation 1 we get

$$1.7 \sin \theta_i = 1.5 \sin 90^\circ$$

$$\theta_i = \sin^{-1}(0.88)$$

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 = $6.6 \times 10^{-34} \text{ Js}$)

- A. $2.34 \times 10^{-3} \text{ eV}$
- B. $1.24 \times 10^{-2} \text{ eV}$
- C. $1.44 \times 10^{-3} \text{ eV}$
- D. $3.46 \times 10^{-2} \text{ eV}$
- E. 0.45 eV

Correct Answer: C

Explanation:

Energy possessed by a photon is given as

$$E = hv \text{ ----- (1)}$$

Frequency is given in GHz so, we need to convert it into Hz.

$$1 \text{ GHz} = 10^9 \text{ Hz}$$

$$350 \text{ GHz} = 3.5 \times 10^{11} \text{ Hz}$$

Putting the values in equation 1 we get

$$E = 6.6 \times 10^{-34} \times 3.5 \times 10^{11}$$

$$\text{Or } E = 2.31 \times 10^{-22} \text{ J}$$

We need to convert energy in Joules into eV as given below

$$1.6 \times 10^{-19} \text{ J} = 1 \text{ eV}$$

$$1 \text{ J} = 1 / (1.6 \times 10^{-19}) \text{ eV}$$

$$\text{Or } 2.31 \times 10^{-22} \text{ J} = 1.44 \times 10^{-3} \text{ eV}$$

Therefore, a photon with frequency of 350 GHz has energy of 1.44×10^{-3} eV. Hence, C is the correct answer option.