Sample paper 3

Question 1

Acceleration of a body is given as
a = (d/t) + (c/t²)
(a is acceleration and t is time)
What would be the dimensional formula of d?

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

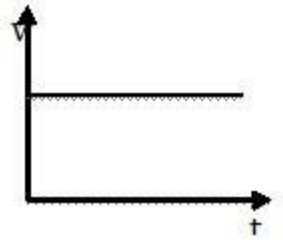
Correct Answer: A

Explanation:

From dimensional analysis we know that dimensional formula of the left hand side of an expression should be the same as the dimensional formula of the individual quantities on the right hand side. Since, SI unit of acceleration is m/s^2. Therefore, dimensional formula of acceleration becomes LT^{-2}. SI unit of time is s. Therefore, its dimensional formula is T. As said earlier, d/t should have the same dimensional formula as a. Let dimensional formula of d be X. Hence, it can be written as
$LT^{-2} = X/T$
$LT^{-1} = X$
Hence, dimensional formula for d is LT^{-1}. Thus, A is the correct answer option.

Question 2

Which of the following is true for a body having the graph given below?



(v is the velocity and t is time taken)

A. Body at rest
B. Body is accelerating
C. Body is undergoing deceleration
D. Body is undergoing positive acceleration
E. Body is moving with constant speed

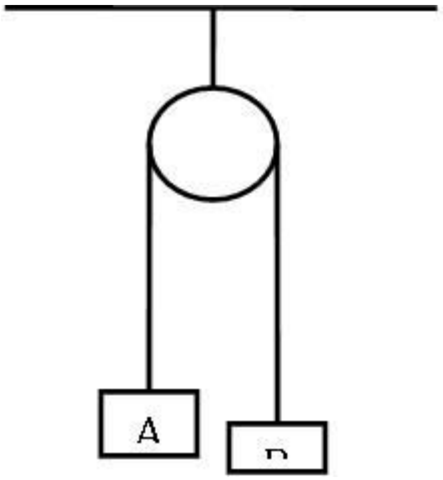
Correct Answer: E

Explanation:

The graph given in the question is between velocity and time. Acceleration is time rate of change of velocity. Velocity is constant here. Therefore, change in velocity is zero and therefore, acceleration is zero. Thus, options, B, C and D are incorrect. Since, velocity is uniform here, the body cannot be at rest and so A is an incorrect option. Therefore, E is the correct answer option.

Question 3

Consider the figure given below for a system of two iron blocks connected with a common pulley. If the block A weighs 200 N, what would be the mass of the iron block B to keep the whole system in static equilibrium?



A. 20.41 kg
B. 15.57 kg
C. 22.23 kg
D. 34.45 kg
E. 21.45 kg

Correct Answer: A

Explanation:

As the whole system is in static equilibrium, there will be no motion in the blocks. In other words, weight of both the iron blocks should be the same. Therefore,
Weight of A = Weight of B -------------- (1)
Weight of A = 200 N --------------- (2)
Using 2 in 1 we get
Weight of B = 200 N ------------- (3)
Weight of a body is given as
W = mg -------------- (4)
Putting the values in equation 4 we get
200 = m * 98 Or m = 20.41 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
$R = \sqrt{(F_1^2 + F_2^2 + 2F_1F^2 \cos \theta)}$ ------------ (1)
As both the forces are acting orthogonally, θ = 90°. Modifying equation 1 we get
$R = \sqrt{(F_1^2 + F_2^2 + 2F_1F^2 \cos 90^\circ)}$
Or $R = \sqrt{(F_1^2 + F_2^2)}$ ------------- (2)
If we take F_1 = 6 N and F_2 = 8 N and putting the values in equation 2 we get
R = 10N
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.
Thus, for only one combination i.e. 6 N and 8 N we have a resultant force of 10 N.
Hence, B is the correct answer option.

Question 5

If a ferry-wheel completes 100 rotations in 15 s, with what velocity is it rotating?

A. 41.87 rad/s
B. 42.34 rad/s
C. 40.56 rad/s
D. 45.45 rad/s
E. 6.67 rad/s

Correct Answer: A

Explanation:

Velocity with which the ferry-wheel is rotating is its angular velocity. It is given as
$\omega = [(N * 2\pi)/ t]$ ----------------- (1)
Putting the values in equation 1 we get
$\omega = [(100 * 2\pi)/ 15]$ ($\pi = 3.14$)
ω = 41.87 rad/s
Therefore, A is the correct answer option.

Question 6

A 5 kg block of ice, kept at some height, has the potential energy of 1000 Joules. What is the height at which the block has been kept?

A. 20.4 m
B. 21.2 m
C. 10.5 m
D. 11.4 m
E. 24.3 m

Correct Answer: A

Explanation:

Potential energy is given as
PE = mgh ---------------- (1)
Putting the values in equation 1 we get
1000 = 5 * 9.8 * h

h = 20.4 m
Hence, A is the correct answer option.

Question 7

For a body in SHM, the maximum displacement of the body on either sides of the equilibrium is known as

A. amplitude
B. wavelength
C. period
D. frequency
E. speed

Correct Answer: A

Explanation:

A body in SHM moves under a restoring force. The restoring force is always directed towards the equilibrium position. Displacement of a body in SHM is measured as the difference between the final position and the position of equilibrium. Amplitude in SHM is the maximum displacement of the body from the position of equilibrium. In other words, it can be said that amplitude is the maximum displacement of the body on either sides of the equilibrium as the body is SHM will continue performing a to and fro motion. Therefore, A is the correct answer option. Time period or period is the time taken to complete one cycle of oscillation. Hence, C is an incorrect option. Wavelength is the distance between two consecutive maxima or minima of a wave. Therefore, B is an incorrect answer option. Frequency of a body is defined as the number of oscillations about the equilibrium position per second. Therefore, D is an incorrect option. The magnitude of velocity with which the body in SHM moves is known as its speed. Therefore, E is an incorrect 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 x 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
$v = f\lambda$ --------------- (1)
As the frequency is given in MHz, we need to convert it into Hz.
1 MHz = 10^6 Hz
Therefore, 400 MHz = 400 * 10^6 Hz
Putting the values in equation 1 we get
$2.5 \times 10^8 = 400 * 10^6 * \lambda$
$\lambda = 0.625$ m
Therefore, wavelength of the FM signal is 0.625 m and thus, B is the correct answer option.

Question 9

A cubical wooden block of side 0.2 m is floating on the surface of water in such a way that some part of wooden surface is outside it. What percentage of the wooden surface is outside the water? (Density of wood = 700 kg/m^3)

A. 10 %
B. 20 %
C. 25 %
D. 35 %
E. 30 %

Correct Answer: E

Explanation:

This question can be solved by using the formula of specific gravity. Specific gravity tells us whether a substance will float or sink down in a fluid. It is given as
$SG = \rho_{body} / \rho_{water}$ ---------------- (1)
Putting the values in equation 1 we get
SG = 700/1000 Or SG = 0.7
Specific gravity provides the fraction of surface of an object inside the fluid. If the specific gravity is equal to 1, then the object will float with zero percent of the surface outside the fluid. If the specific gravity is more than 1, then the object will sink completely inside the fluid. Since, specific gravity here is 0.7, percentage of the wooden surface inside the level of water is
%SG = 0.7 * 100 Or %SG = 70%
Therefore, 70 % of the block is inside the water and 30 % of the block is outside the water.
Hence, E is the correct answer option.

Question 10

20 gram of a substance evaporates at 500 K by absorbing 740 J of energy. If the specific heat of the substance is 1000 J/kg K, what is the final temperature of the substance?

A. 400 K
B. 413 K
C. 537 K
D. 513 K
E. 637 K

Correct Answer: C

Explanation:

This question can be solved by
$Q = mc \Delta T$ ---------------- (1)
As mass is given in grams we need to convert it into kg.
$1g = 10^{-3}$ kg
20g = 0.02kg
Change in temperature is given as
$\Delta T = T_2 - T_1$
Putting the values in equation 1 we get
$740 = 0.02 * 1000 * (T_2 - 500)$ Or $T_2 = 537$ K
Therefore, C is the correct answer option.

Question 11

Potential difference of 150 V is applied across an aluminum conductor of length 2.5 m. If the density of free electrons in the conductor is 2 x 10^{23} m^{-3}, what would be the average drift velocity of the electrons? (Conductivity of aluminum is 3.5 2 x 10^{7} Ω^{-1} m^{-1} and charge on electron = 1.6 x 10^{-19} C)

A. 650.25 m/s
B. 450.65 m/s
C. 656.25 m/s
D. 414.55 m/s
E. 710.23 m/s

Correct Answer: C

Explanation:

Average drift velocity of an electron is given as
$v_d = \sigma E$ / ne -------------- (1)
Electric field is given as
E = v/l --------------- (2)
Putting the values in equation 2 we get E = 150/2.5 Or E = 60 V/m
Putting the values in equation 1 we get v_d = [(3.5 x 10^{7} * 60) / (2 x 10^{25} * 1.6 x 10^{-19})]
Or, v_d = (2.1 x 10^{9}) / 3.2 x 10^{6}
Or v_d = 656.25 m.s
Therefore, C is the correct answer option.

Question 12

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

A. 3.2 x 10^{-17} N
B. 1.6 x 10^{-17} N
C. 4.8 x 10^{-17} N
D. 2.4 x 10^{-17} N
E. 10^{-17} N

Correct Answer: B

Explanation:

Force experienced by the beta particle is given as
F = qvB sin θ ---------------- (1)
As the beta particle is moving perpendicularly to the magnetic field, θ = 90°. Charge onabeta particle is equal to the charge onanelectron; Putting the values in equation 1 we get
F = 1.6 x 10^{-19} x 10^{4} x 0.01 x sin 90°
Or, F = 1.6 x 10^{-17} * 1 N
Or, F = 1.6 x 10^{-17} Hence, B is the correct answer option.

Question 13

A circular coil of radius 0.1 m consists of 10 turns. If the current flowing through the coil is measured to be 1.5 A, what would be the magnetic field at the center of the coil? (Permeability of free space is 4π x 10^{-7} WbA^{-1} m^{-1})

A. 8.5 x 10^{-5} T
B. 7.42 x 10^{-5} T
C. 9.42 x 10^{-5} T
D. 6.32 x 10^{-5} T
E. 5.52 x 10^{-5} T

Correct Answer: C

Explanation:

Magnetic field at the center of a coil due to the current flowing in it is given as
B = (μ_o / 4 π)(2πnI / r) -------------- (1)
Putting the values in equation 1 we get
B = [(4 π x 10^{-7}) / 4 π] * [(2π * 10 * 1.5)/0.1]
Or B = 10^{-7} * [(2 * 3.14 * 10 * 1.5) / 0.1] (π = 3.14)
Or, B = 10^{-7} * 942
Or, B = 9.42 x 10 $^{-5}$ T
Hence, C is the correct answer option.

Question 14

Refractive index of diamond with respect to air is 2.4 and the refractive index of water with respect to air is 1.33. What would be the refractive index of diamond with respect to water? (Refractive index of air = 1)

A. 1.51
B. 0.55
C. 1.8
D. 0.75
E. 0.42

Correct Answer: C

Explanation:

Refractive index of one medium with respect to another medium is given as
$_2\mu^1 = \mu^2 / \mu^1$

Here we have been given refractive index of diamond with respect to air = 2.4 i.e.

2.4 = $\mu_{diamond}$ /1 Or $\mu_{diamond}$ = 2.4

Also, refractive index of water with respect to air = 1.33 i.e.

1.33 = μ_{water} /1 Or μ_{water} = 1.33

Thus, refractive index of diamond with respect to water becomes

$_{diamond}\mu^{water}$ = 2.4 / 1.33

Or $_{diamond}\mu^{water} = 1.80$
Thus, C is the correct answer option.

Question 15

What is the Joule equivalent of 1 eV? (Charge on electron = 1.6 x 10^{-19} C)

A. 1.6 x 10^{-19} J
B. 3.2 x 10^{-19} J
C. 3.2 x 10^{-13} J
D. 1.6 x 10^{-13} J
E. 1 J

Correct Answer: A

Explanation:

Joule is the SI unit of energy. eV is also a unit of energy but for microscopic charged particles. One electron volt (eV)is defined as the energy possessed by an electron moving in a unit potential field.
We know that energy of a charged particle in a potential field is given as
E = q V J ------------- (1)
For an electronin a potential field of 1 V,energy can be expressed by using equation 1 as
E = e V J ------------- (2)
Putting the value in equation 2 we get
1 ev = 1.6 x 10^{-19} * 1 J
Or 1 ev = 1.6 x 10^{-19} J
Therefore, A is the correct answer option.