Sample paper 1

Question 1

What is the dimensional formula of torque?

A. MLT^{-2}
B. MT^{-2}
C. ML^2T^{-2}
D. MLT^{-1}
E. ML^3T^{-2}

Correct Answer: C

Explanation:

Torque is the turning effect of force applied on a body. It is given as
t = r x F
Where
t is the torque vector;
r is the displacement vector;
F is the force vector;
Since dimensional formula of force is MLT^{-2} and that of displacement is L hence, dimensional formula of torque becomes
$MLT^{-2} * L$
ML^2T^{-2}
Therefore, C is the correct answer option.

Question 2

A car moving at 25 m/s suddenly stops by applying brakes on observing a stoplight. If the time taken during the process of stopping is 1.5 s, what is the displacement of the car?

A. 17.55 m
B. 18.75 m
C. 16.25 m
D. 15.35 m
E. 17.75 m

Correct Answer: B

Explanation:

This problem can be solved by applying the kinematic equation of motion as shown below
v = u + at ------------ (1)
Where
v is the final velocity of the car;
u is the initial velocity of the car = 25 m/s;
a is the acceleration the car is undergoing;
t is the time under consideration = 1.5 s;
Since the car finally stops, hence v = 0 m/s. Putting the values in equation 1 we get
0 = 25 + a *1.5
Or, -25 = 1.5a --------------- (2)
Negative sign is coming because the car finally comes to rest and it is undergoing negative acceleration. We can neglect the negative sign here. Therefore, equation 2 becomes

a = 25/1.5
Or, a = 16.67 m/s^2

Since, we know initial and final velocities and acceleration as well we can use kinematic equation
$v^2 = u^2 - 2as$ -------------- (3)
to solve for displacement.
Where
S is the displacement of the car; We have taken the negative sign for acceleration here due to the fact that acceleration is negative. Putting the values of v, u, a in equation 3 we get
$0 = 25^2 - 2 \times 16.67 \times S$
Or, $25^2 = 2 \times 16.67 \times S$
Or, $S = 25^2/(2*16.67)$
Or, S = 625/33.34
Or, S = 18.75m
Hence, B is the correct answer option.

Question 3

Net force acting on a body moving with constant velocity is zero. Which of the following is incorrect?

A. Body will slow down
B. Body will move faster
C. Body will stop
D. Body will continue moving with same velocity
E. Body will accelerate

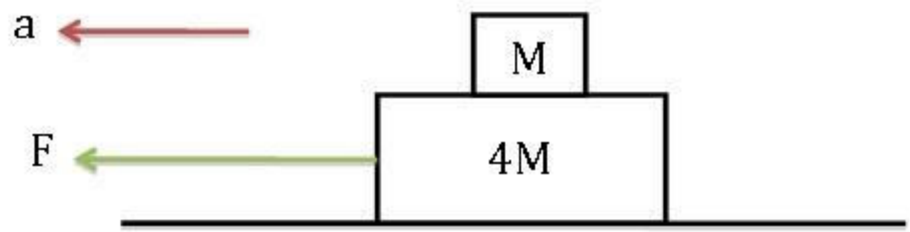
Correct Answer: D

Explanation:

A body moving with constant velocity or at rest is the condition of static equilibrium. For static equilibrium, we need balanced force that means all the forces acting on the body balance each other and in this way the net force acting on the body becomes zero. Therefore, only option D is correct amongst the first four the options given above. Body cannot accelerate, as acceleration is time rate of change of velocity. If velocity is remaining constant, the acceleration will become zero. Therefore, E is an incorrect option.

Question 4

Two blocks of masses M and 4 M are moving under the effect of the same force, F on a frictionless table as shown below. What would be acceleration of the smaller mass? (Assume smaller mass is at rest with respect to the larger mass)



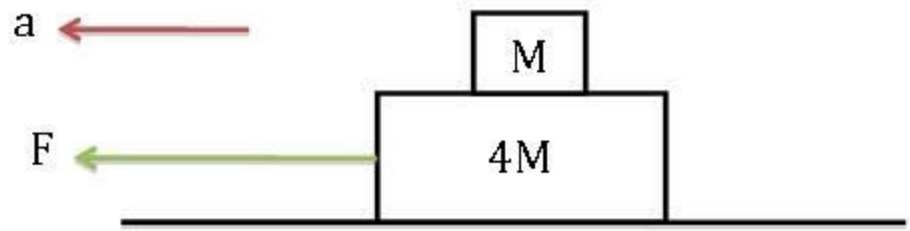
A. F/4M
B. F/M

C. F/5M
D. F/3M
E. F/2M

Correct Answer: C

Explanation:

Since the table is frictionless, hence both the bodies will continue moving under the common force F and will have same acceleration. Since it is brought out in the question that the smaller block is not moving over the larger block hence, both the blocks will move as a combined body.
The situation above is shown below.



As both the bodies are moving together, hence, their combined mass becomes
$M_{total} = M + 4M$
Or, $M_{total} = 5M$
Common force acting on the bodies is F. Therefore, by Newton's second law of motion we have
F = ma ------------- (1)
Where
F is the force applied;
m is the mass of the body;
a is the acceleration of both the blocks;
Mass of the body here is $M_{total} = 5M$. Putting the values in equation 1 we get
F = 5M * a
Or, F/5M = a
Hence, with this acceleration both the smaller and the larger mass will move under the effect of common force, F.
Therefore, C is the correct answer option.

Question 5

What would be the moment of inertia of a thin-walled fluorescent lamp having radius of 3 cm and mass of 50 grams?

A. 4.5×10^{-5} kgm^2
B. 3.5×10^{-5} kgm^2
C. 3.5×10^{-6} kgm^2
D. 4.5×10^{-6} kgm^2
E. 4×10^{6} kgm^2

Correct Answer: A

Explanation:

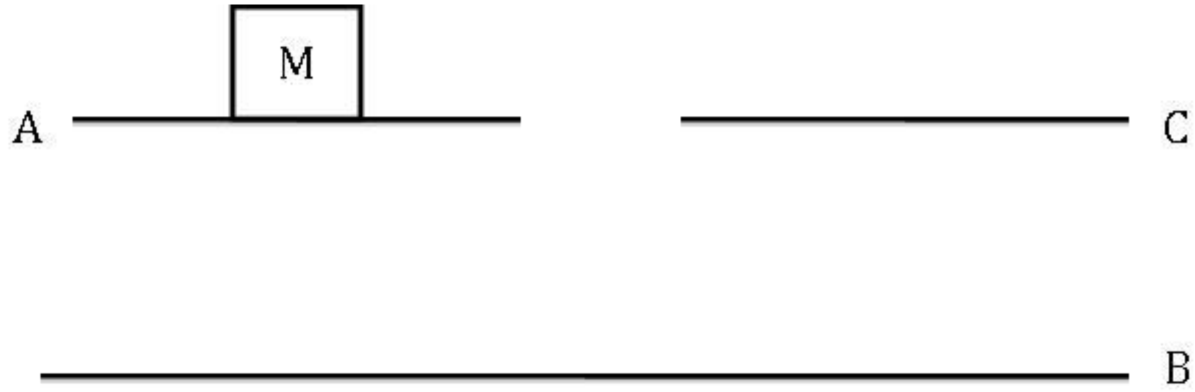
Moment of inertia of thin-walled fluorescent lamp is given as
$I = MR^2$ ---------------- (1)
Where
I is the moment of inertia;

M is the mass of the lamp = 50 g;
R is the radius of the lamp = 3 cm;
We have been given mass in grams so, we need to convert it into kg.
1 g = 10^{-3}kg
50g = 50 * 10^{-3}kg
50g = 0.05 kg

Also, radius is given in cm so we need to convert it into m.
1 cm = 10^{-2}m
3 cm = 3 * 10^{-2}m
3 cm = 0.03 m
Putting the values of M and R in equation 1 we get
I = 0.05 * 0.03^2
Or, I = 4.5 * 10^{-5} kg m^2
Therefore, A is the correct answer option.

Question 6

Consider the figure given below. B is the nodal plane or ground. A body of mass M is kept on a horizontal plane A at a certain height above the plane B. Plane C is at same height from the ground (B) as that of plane A. Which of the following statements is correct?



Potential energy of the body is non-zero with respect to the plane A

Potential energy of the body is non-zero with respect to the plane C

Potential energy of the body is non-zero with respect to the plane B

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

Correct Answer: C

Explanation:

Potential energy is the energy stored in a body by virtue of its height from the reference plane.
Potential energy is given as
PE = mgh --------------- (1)
Where

m is the mass of the body;
g is the acceleration due to gravity;
h is the height of the body above the reference plane;

The reference plane plays a vital role in defining the potential energy of a body. Most often reference plane is taken as the ground and hence plane B is the reference plane here. We will discuss potential energy of the body for all the planes individually.
For plane A, the height of the body is zero as it is kept on the same plane A. Hence, putting the value of h in equation 1 we get
PE = 0
Therefore, potential energy of the body is zero with respect to the plane A. Thus, A is an incorrect option.
Both the planes A and C are at same height above the reference plane. Therefore, potential energy of the body with respect to the plane C is same as that in respect of A. Hence, B is incorrect as well.
Since the plane A is at some height from the reference plane, h will have a non-zero value. Therefore, potential energy of the body with respect to the ground plane will have some non-zero value. Thus, C is the correct answer option. In the view of the above, D and E are also incorrect options.

Question 7

Displacement of a particle in SHM is given as
x(t) = 23 sin(314t) cm
What is the amplitude and frequency of oscillation of the particle?

A. 2.6 cm, 40 Hz
B. 2.3 cm, 40 Hz
C. 2.3 cm, 50 Hz
D. 2.6 cm, 50 Hz
E. 3.14 cm, 314 Hz

Correct Answer: C

Explanation:

General expression for displacement of a body in SHM is given as
X(t) = A sin(ωt) ----------- (1)
Where
X(t) is the displacement of the particle;
A is the amplitude of the oscillation;
ω is the angular frequency;
Displacement of a particle as given in the question is
X(t) = 23 sin(314t) cm ------------- (2)
Comparing equation 1 with 2 we get
A = 2.3 cm and ω = 314 rad/s
Angular frequency is related to frequency as ω = 2Πf ----------- (3)
Where
f is the frequency of the oscillation;
Putting the value of in equation 3 we get
314 = 2Πf
Or, 314/(2*Π) = f
Or, 314/(2*3.14) = f
(Π = 3.14)
Or, f = 50 Hz

Hence, C is the correct answer option.

Question 8

Which of the following do not require any medium to propagate?

A. Sound waves
B. Seismic waves
C. Tides
D. Light waves
E. Waves on the surface of water

Correct Answer: D

Explanation:

Sound waves can only propagate in the presence of a medium like solid, liquid or gas. Sound waves cannot propagate in the absence of a medium. Therefore, A is an incorrect option. Seismic waves are generated due to the fault in tectonic plates of the Earth. Seismic waves originate from a point and travel through the Earth's layers. Hence, without the presence of Earth's layers seismic waves cannot propagate. Hence, B is an incorrect option. Tides and waves on the surface of water originate at a point of disturbance and progress along all directions. Without any medium surrounding the point where the tides or surface waves on water originate, the waves will not propagate. The medium for tides and surface waves on water is essentially liquid. Therefore, C and E are incorrect options as well. Light waves do not require any medium to propagate. For example, light waves coming from the Sun travel most of the distance through the outer space that is devoid of any medium. Therefore, D is the correct answer option

Question 9

A cylinder of height 2.5 m is filled completely with water. A hole is made at the bottom of the cylinder in such a way that water is coming out of it. What is the velocity of water coming out of the cylinder?

A. 6.4 m/s
B. 4 m/s
C. 9.8 m/s
D. 2.5 m/s
E. 7 m/s

Correct Answer: E

Explanation:

Velocity of water coming out of a cylinder is given as
$v^2 = 2gh$ ----------------- (1)
Where
v is the velocity of the water coming out of the cylinder;
h is the height to which water is filled= 2.5 m;
g is the acceleration due to gravity = 9.8 m/s2;
Putting the values of h and g in equation 1 we get
$v^2 = 2 * 9.8 * 2.5$
Or, $v^2 = 49$
Or, v = 7 m/s
Hence, E is the correct answer option.

Question 10

An object A of mass 40 kg at 60^0 C has internal energy of 4000 J. If it is kept in contact with another object B of mass 40 kg at 65^0 C having internal energy 4500 J, then which of the following statements is true regarding heat transfer? (Assume boundary of contact can allow heat transfer to take place)

A. Heat will flow from A to B
B. Heat will flow from B to A
C. No heat will flow between the objects A and B
D. Temperature of A decreases
E. Temperature of B increases

Correct Answer: B

Heat always flows from a hot body to a cooler body. In other words, heat flows from a body at a higher temperature to a body at a lower temperature. If an object A, at 60^0 C is kept in contact with another object B, at 65^0 C, then this means that object A is at lower temperature than that of object B. Hence, heat will flow from B to A. Also, as the heat is transferred from B to A, temperature of B will reduce but temperature of A will increase to reach thermal equilibrium. Thus, B is the correct answer option and A, C, D and E are incorrect answer options.

Question 11

How many electronic charges comprise a coulomb of charge?

A. 6×10^{18}
B. 10^{18}
C. 2×10^{18}
D. 2×10^{19}
E. 5×10^{15}

Correct Answer: A

Explanation:

Charge is given as
Q = ne --------------- (1)
Where
Q is one coulomb of charge;
n is the number of electronic charges;
e is the charge on electron = $1.6 * 10^{-19}$ C;
Putting the values in equation 1 we get
$1 = n * 1.6 * 10^{-19}$
Or, $n = 6.25 * 10^{18}$
Since n is a number therefore number of electronic charges that make one coulomb of charge is $6 * 10^{18}$. Therefore, A is the correct answer option

Question 12

Three batteries each of 25 V having zero internal resistance are connected in series with a resistance of 100 Ω. What would be the current in the circuit?

A. 4 A
B. 0.75 A
C. 6.5 A
D. 0.33 A
E. 0.25 A

Correct Answer: B

Explanation:

Since the batteries are connected in series, equivalent potential of batteries can be found by adding the individual potential. Let equivalent potential be V_{eq}. Therefore, $V_{eq} = 25 + 25 + 25$
Or, $V_{eq} = 3 * 25$ V
Or, $V_{eq} = 75$V
Since internal resistance of the batteries is zero, only resistance to which the equivalent potential is connected is 100 Ω. Hence, current flowing through the circuit can be found by Ohm's law. Ohm's law is given as
V = IR -------------- (1)
Where
V is the potential of the cell = 75 V;
I is the current flowing through the circuit;
R is the equivalent resistance of the circuit = 100 Ω
Putting the values of V and R in equation 1 we get
75 = I * 100
Or, I = 75/100
Or, I = 0.75 A
Therefore, B is the correct answer option.

Question 13

Keeping the current same in a circular wire, radius is getting doubled. What will the new value of magnetic moment be, if the initial magnetic moment is 3×10^{-5} Am²?

A. 3×10^{-5} Am^2
B. 0.75×10^{-5} Am^2
C. 4×10^{-5} Am^2
D. 3.2×10^{-4} Am^2
E. 1.2×10^{-4} Am^2

Correct Answer: E

Explanation:

Magnetic moment is given as
M = IA ------------ (1)

Where
M is the magnetic moment;
I is the current flowing in the wire;
A is the area of the circular loop;

Since the wire is of circular shape hence, area of the circular loop is given as
$A = \pi r^2$ -------------- (2)

Where
r is the radius of the wire;
Let A_1 and r_1 be the area and radius of the initial wire. Therefore, expressing equation 2 in terms of A_1 and r_1 we get
$A_1 = \pi r_1^2$----------- (3)

Similarly, let A_2 and r_2 be the area and radius of the final wire. Therefore, expressing equation 2 in terms of $A_2$and r_2 we get
$A_2 = \pi r_2^2$ ------------ (4)

Since it is given in the question radius of the final wire is twice that of the initial wire hence, $r_2 = 2r_1$
Using the value of r_2 in equation 4 we get
$A_2 = \pi(2r_1)^2$ Or, $A_2 = 4\pi r_1^2$ ------------- (5)

Comparing equation 5 with 3 we find that final area can be expressed in terms of initial area and is given as
$A_2 = 4\pi r_1^2$
$A_2 = 4A_1$ ------------------ (6)

Expressing initial and final magnetic moment in equation 1 in terms of initial area and final area we get
$M_1 = IA_1$ ---------------- (7)

And, $M_2 = IA_2$ ---------- (8)

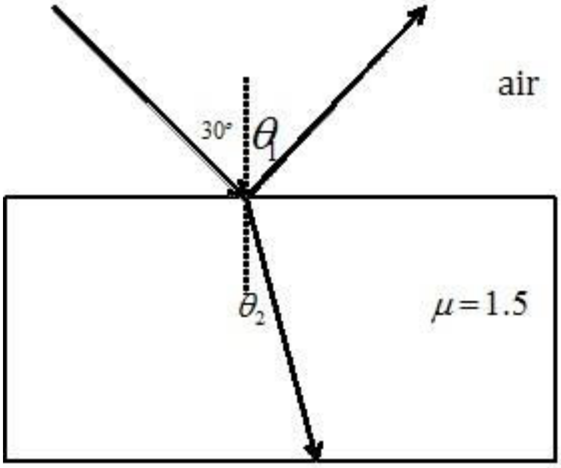
Both initial and final current in the wire is same. Dividing equation 8 by equation 7 we get
$M_2/ M_1 = (IA_2)/(IA_1)$ ---------------- (9)

Cancelling out the common term, in 9 we get
$M_2/ M_1 = A_2/A_1$ --------------- (10)
Using equation 6 in 10 we get
$M_2/ M_1 = 4A_2/A_1$
Or, $M_2/ M_1 = 4$
Therefore, $M_2 = 4 M_1$ -------------- (11)

Putting the value of M_1 in equation 11 we get $M_2 = 4 * 3 * 10^{-5}$ Or, $M_2 = 1.2 * 10^{-4}$ Am^2
Hence, E is the correct answer option.

Question 14

Consider the figure given below.



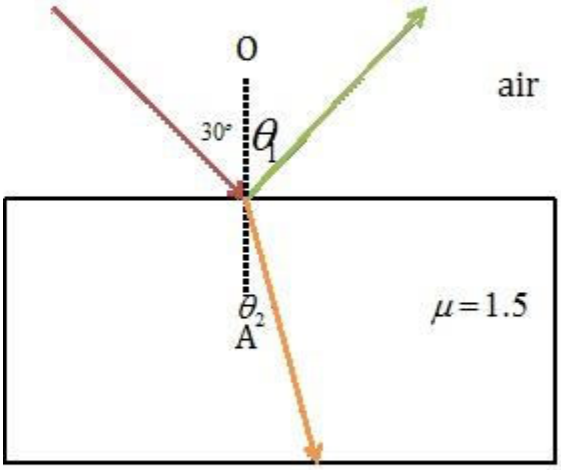
What are the values of Θ_1 and Θ_2 for the figure if a ray of light is incident at from air to a medium of refractive index 1.5?

A. $\sin^{-1}(1/3.7)$
B. $\cos^{-1}(1/3)$
C. $\tan^{-1}(1/3.7)$
D. $\cot^{-1}(1/3)$
E. $\sin^{-1}(1/3)$

Correct Answer: E

Explanation:

In the figure given below, the brown arrow represents the incident ray, the green arrow represents the transmitted or the reflected ray, and the orange arrow represents the refracted ray. OA represents the normal to the interface between the air and the medium.



Since the incident light is travelling from one medium to another, some part of it will be reflected and some will be refracted. As we know from the property of reflection that, angle of incidence is same as angle of reflection, the green arrow, which is the reflected light will make the same angle with the normal as made by the incident beam with the normal. Therefore,
$\theta_1 = 30^o$
θ_2 can be found by applying Snell's law. According to Snell's law we have

$\mu_1 \sin \theta_i = \mu_2 + \sin \theta_r$ ---------------- (1)
Where
μ_1 is the refractive index of medium 1 (here air = 1);
θ_i is the angle of incidence = 30^o ;
μ_2 is the refractive index of medium 2 = 1.5;
θ_r is the angle of refraction = θ_2 ;

Putting these values in equation 1 we get
Or, $1 * \sin 30^o = 1.5 * \sin \theta_r$
Or, $1/2 = 1.5 * \sin \theta_r$
Or, $1/(2*1.5) = \sin \theta_r$
Or, $1/3 = \sin \theta_r$
Or, $\theta_r = \sin^{-1} (1/3)$
As θ_r is same as θ_2
. The angle of refraction is $\sin^{-1}$ (1/3).
Hence, E is the correct answer option.

Question 15

Which of the following gets deflected by electric field?

A. Gamma rays
B. Infrared rays
C. Beta rays
D. Neutrons
E. X-ray

Correct Answer: C

Explanation:

Electric field can be negative or positive in nature. If the electric field is created by negative charges then the electric field is negative and if the electric field is created by positive charges then the electric field is positive. Depending on the type of the charged particle passing through the region of electric field, deflection can be either attractive or repulsive. Since gamma rays have no charge they will move further into the electric field without being deflected. Hence, A is an incorrect option. Infrared rays consist of uncharged particles and therefore, there would not be any deflection from the normal path. Thus, B is an incorrect option. Beta rays are equivalent to electrons i.e. beta rays have the same charge as that on electron. Hence, when beta rays pass through an electric field they will either get attracted or repelled depending on the nature of the electric field. Thus, C is the correct answer option. Neutrons are neutral like gamma rays or infrared rays. Hence, they will not show any deflection while passing through the electric field. Therefore, D is an incorrect option. X-rays consists of neutral particles. Due to this, when they pass through a region of electric field, they undergo no deflection. Thus, E is an incorrect option as well.