Sample paper 5

Question 1

What would be the dimensional formula for the ratio between acceleration due to gravity and gravitational constant?

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

Correct Answer: C

Explanation:

Acceleration due to gravity at Earth is expressed as

$g = GM / R^2$ ---------- (1)
Since we have to find the dimensional formula for the ratio between g and G, equation 1 can be written as

$g / G = M / R^2$ ---------- (2)

Thus, dimensional formula of g/G can be found by calculating the dimensional formula for M / R^2.
Since, dimensional formula of M is M and R is L hence, equation 2 can be written as
$g / G = M / L^2$
Or $g / G = ML^{-2}$
Thus, C is the correct answer option.

Question 2

A car speeds up from 15 m/s to 27 m/s in 45 s. What would be the acceleration of the car?

A. 0.15 m/s^2
B. 0.32 m/s^2
C. 0.38 m/s^2
D. 0.27 m/s^2
E. 0.4 m/s^2

Correct Answer: D

Explanation:

Here the initial speed, the final speed and the time taken are given and so we can use the kinematic equation

$v = u + at$ ---------- (1)

Putting these values in equation 1 we get
$27 = 15 + a * 45$
Or $a = 0.27$ m/s^2
Therefore, D is the correct answer option.

Question 3

Consider the following conclusions based on Newton's first law.

Acceleration will be zero for a body obeying Newton's first law

A balanced force is required to keep a body at rest or to keep it moving with uniform speed

An unbalanced force is required to keep a body at rest or to keep it moving with uniform speed

Based on the conclusions above, which of the following statement(s) is/are true?

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

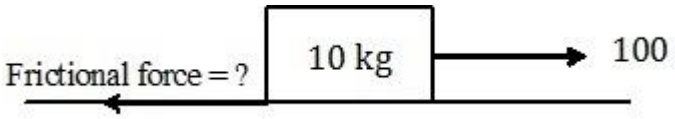
Correct Answer: D

Explanation:

If the net force acting on a body is zero then it means that theresultant of all the forces acting on the body is zero. Balanced forces produce zero net force acting on a body. Thus, if a body is acted upon by a balanced force, then net force acting on it is zero and hence, it will continue to retain its initial motion. Unbalanced forces have some non-zero value of force acting on a body and the body continues moving with non-uniform speedalong the unbalanced force. Acceleration is time rate of change of velocity. It can also be concluded from Newton's first law that as the velocity is uniform, change in velocity is zero and so is the acceleration of the body. Thus in view of the above discussion statements, 1 and 2 are correct and 3isincorrect. Hence, D is the correct answer option.

Question 4

Consider the figure given below. A block of wood of mass 10 kg is kept on a rough surface. Which of the following statements is true in respect of the frictional force that will develop such that the block moves in the direction of a force of 100 N as shown in the figure below?



A. Frictional force < 100 N
B. Frictional force > 100 N
C. Frictional force = 100 N
D. Frictional force = 0 N
E. Not enough data is provided

Correct Answer: A

Explanation:

Frictional force develops due to the actual motion of a block on a surface. As the surface is rough, some frictional force will develop against the force of 100 N. Hence, D is an incorrect option. If the applied force is greater than the frictional force then only will the block of wood move. Hence, A is the correct answer option and B is an incorrect option. Also, if the frictional force is the same as the

applied force, then the block of wood is at the verge of moving but it will show no physical motion. Therefore, C is an incorrect option. In view of the above discussion, E is an incorrect option.

Question 5

A wheel is rotating with a constant acceleration of 5 rad/s^2. After an angular displacement of 2π radians, the angular velocity of the wheel becomes 70 rad/s. What was the initial angular velocity of the wheel?

A. 6.5 rad/s
B. 7.8 rad/s
C. 7.2 rad/s
D. 5.6 rad/s
E. 7.1 rad/s

Correct Answer: C

Explanation:

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

$\omega_f = \omega_i + 2\alpha\theta$ ---------- (1)

Putting the values in equation 1 we get
$70 = \omega_i + (2 * 5 * 2\pi)$ ($\pi = 3.14$)
$70 = \omega_i + 62.8$ Or $\omega_i = 7.2$ rad/s
Therefore, C is the correct answer option.

Question 6

A ball weighing 70 N falls from a height of 3 m. What would be the kinetic energy of the ball when it hits the ground?

A. 200 J
B. 195 J
C. 210 J
D. 180 J
E. 22.5 J

Correct Answer: C

Explanation:

Energy or work done is given as

$E = Fd$ ---------- (1)

Putting the values in equation 1 we get
$E = 70 * 30$ Or $E = 210$ J

Therefore, C is the correct answer option.

Question 7

If the amplitude of a body in SHM becomes one-half of the initial value, what would be the ratio between the final total energy and initial total energy?

A. 1:2
B. 1:1
C. 2:1
D. 1:4
E. 4:1

Correct Answer: D

Explanation:

Total energy of a body in SHM is given as

$E = (1/2)kA^2$ ---------- (1)

Initial energy is given by $E^1 = (1/2)kA_1^2$ ---------- (2)

Final energy is given by $E^2 = (1/2)kA_2^2$ ---------- (3)

Since $A_2 = A_1 / 2$, $E^2 = (1/4)[(1/2)kA_1^2]$ ---------- (5)

Comparing equation 5 with 2 we get

$E^2 : E^2 = 1 : 4$

Therefore, D is the correct answer option.

Question 8

A seismic wave originates at point A and travels along every direction with a speed of 1.6 m/s. If the seismic wave reaches a point B which is at a distance of 2000 Km from A, what would be the time difference between the points A and Bin minutes?

A. 20.83 minutes
B. 18.57 minutes
C. 15.78 minutes
D. 21.56 minutes
E. 19.56 minutes

Correct Answer: A

Explanation:

A seismic wave originates at point A, travels along every direction and reaches point B. As it originates from A, it will reach point B after some timeandthis is thetime difference. Time difference can be given as

Time difference = distance / speed ---------- (1)

Distance between A and B is given as 2000 Km and speed of the seismic wave = 1.6 km/s. Therefore, putting these values in equation 1 we get

Time difference = 2000/1.6 seconds = 1250 seconds

1 s = 1 / 60 minutes

Therefore, A is the correct answer option.

Question 9

A cubical block of plastic of side length 0.1 m encloses a fluid of density 990 kg/m^3. What is the weight of the block? (Assume weight of the block is only due to the fluid inside it)

A. 9.7 N
B. 4.8 N
C. 5.8 N
D. 3.6 N
E. 6.5 N

Correct Answer: A

Explanation:

Weight is given as W = mg ---------- (1)

Mass of the block can be given as m = V ρ ---------- (2)

Volume of a cube is given as V = $(side)^3$ ---------- (3)

Therefore, putting the value in equation 3 we get

V = $(0.1)^3$ Or V = 10^{-3} m^3

Putting the values of V and density in equation 2 we get m = 0.99 kg

Putting the value of m and g in equation 1 we get W = 9.7 N

Therefore, A is the correct answer option.

Question 10

A thermal power plant operates between the temperature range of 600 K and 1000 K. What is the efficiency of the plant?

A. 30 %
B. 40 %
C. 45 %
D. 34 %
E. 100 %

Correct Answer: B

Explanation:

Efficiency of a plant is given as

$\eta = 1 - (T_2 / T_1)$ ---------- (1)

Putting the values in equation 1 we get $\eta = 1 - 600 / 1000$
Or $\% \eta = 40\%$
Therefore, B is the correct answer option.

Question 11

A water drop of mass 10^{-9} kg consists of free ions of charge 2.5×10^{-20} C. If the water drop is held at rest by an external field, what is the external field?

A. 2.55×10^{10} N/C
B. 3.92×10^{11} N/C
C. 4.56×10^{10} N/C
D. -4.56×10^{10} N/C
E. -3.92×10^{11} N/C

Correct Answer: B

Explanation:

Here, weight of the water drop is balanced by the electric force. Thus, we need to equate both kinds of forces to find the value of the electric field. Weight of the water drop is given as

W = mg ---------- (1)

Putting the values in equation 1 we get
$W = 10^{-9} * 9.8$
Or $W = 9.8 \times 10^{-9}$ N
Electric force is given as F = qE ---------- (2)

Putting the values in equation 2 we get $F = 2.5 \times 10^{-20} * E$ ---------- (3)

As discussed above, weight of the water drop is equal to the electric force and hence, equating weight with equation 3 we get $E = 3.92 \times 10^{11}$ N/C

Hence, B is the correct answer option.

Question 12

The equivalent resistance of two wires connected in series is 50Ω. If they are connected in parallel their resistance becomes 8Ω, what is the resistance of both the conductors?

A. 40Ω and 10Ω
B. 20Ω and 10Ω
C. 20Ω and 20Ω
D. 40Ω and 20Ω
E. cannot be found

Correct Answer: A

Explanation:

Let R_1 and R_2 be the resistances of the two wires connected in series and parallel respectively.

$R_s = R_1 + R_2 = 50\Omega$; ---------- (1)

And, $R_p = R_1 \parallel R_2 = [(R_1 * R_2)/(R_1 + R_2)] = 80\Omega$ ---------- (2)

From equation 1 $R_2 = 50 - R_1$ ---------- (3)

Putting equation 3 in 2 we get

$[(R_1 * (50 - R_1)/(R_1 + (50 - R_1))] = 8$

Or $R_1 = 10\Omega$

Putting the value of R_1in equation 3 we get

$R_2 = 40\Omega$

Therefore, A is the correct answer option.

Question 13

A beam of electrons enters normally in a region of magnetic field of 0.01 T with a velocity of 10^6 m/s. What is the radius of the curved path traced by the beam of electrons? (Charge on electron = 1.6 x 10^{-19}C)

A. 4.5×10^{-4} m
B. 3.6×10^{-4} m
C. 5.7×10^{-4} m
D. 2.8×10^{-4} m
E. Cannot be determined

Correct Answer: C

Explanation:

If a charged particle enters a region of magnetic field, it experiences a force due to which the charged particles follow a curved path. The radius of the curved path is given as

$r = (mv)/(qB)$ ---------- (1)

Putting the values in equation 1 we get

$r = [(9.1 \times 10^{-31} \times 10^6) / (1.6 \times 10^{-19} * 0.01)]$

$r = 5.7 \times 10^{-4}$ m

Therefore, C is the correct answer option.

Question 14

If a ray of light is incident on ice from air at an angle of 30°, which of the following is true? (Refractive index of ice = 1.309 and refractive index of air = 1)

A. Angle of refraction = $\sin^{-1}(0.382)$ and air is denser than ice
B. Angle of refraction = $\sin^{-1}(2.6)$ and ice is denser than air
C. Angle of refraction = $\sin^{-1}(0.382)$ and ice is denser than air
D. Angle of refraction = $\cos^{-1}(0.382)$ and air is denser than air
E. Angle of refraction = $\tan^{-1}(0.382)$ and ice is denser than air

Correct Answer: C

Explanation:

Light entering from one medium to another medium of a different refractive index bends and this bending is governed by Snell's law. It is given as

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

Putting the values in equation 1 we get

$1 * \sin 30^o = 1.309 \times \sin \theta_r$

Or $\theta_r = \sin^{-1} (0.382)$

Therefore, angle of refraction is $\sin^{-1} (0.382)$. Whether a medium is denser or rarer is determined by the refractive index of the medium. Higher the refractive index, denser will be the medium. Since, refractive index of ice (1.309) is more than that of air (1), ice is denser than air. Hence, C is the correct answer option.

Question 15

What is the momentum of a photon of energy 1 eV?

1.23×10^{-28} $kgms^{-1}$

1.87×10^{-28} $kgms^{-1}$

1.6×10^{-19} $kgms^{-1}$

5.33×10^{-28} $kgms^{-1}$

4.5×10^{-19} $kgms^{-1}$

Correct Answer: D

Explanation:

Energy of a photon is given as $E = mc^2$ ---------- (1)

Equation 1 can be written as $E = (mc)c$ ---------- (2)

Momentum of a photon is defined as the product of mass and velocity of the photon. It is given as $p = mc$ ---------- (3)

Using equation 3 in 2 we get E = pc ---------- (4)

Energy of the photon is given as 1 eV (1 eV = 1.6×10^{-19} J). As energy is given in eV, we need to convert it into Joules (as Joule is the SI unit of energy).

Putting the values in equation 4 we get $p = 5.33 \times 10^{-28}$ $kgms^{-1}$

Hence, D is the correct answer option.