Question 1

Addition of vector A = 2i + 3j + k with vector B, results in unit vector along z-axis. What is the vector B?

- A. -2 i + 3j
- B. 2i + 3j
- C. 2i - 3j
- D. -2i -3j
- E. 2i

Correct Answer: D

Explanation:

Unit vector has the magnitude of 1 and points along z-axis here. Let C be the vector resulting from the addition of A and B. Therefore,
C = A + B ------------- (1)

Putting the value of A in equation 1 we get

C = 2i + 3j + k + B -------------- (2)

Vector C is the unit vector along z-axis. Thus, it has the magnitude of 1 and points along z-axis and can be written as
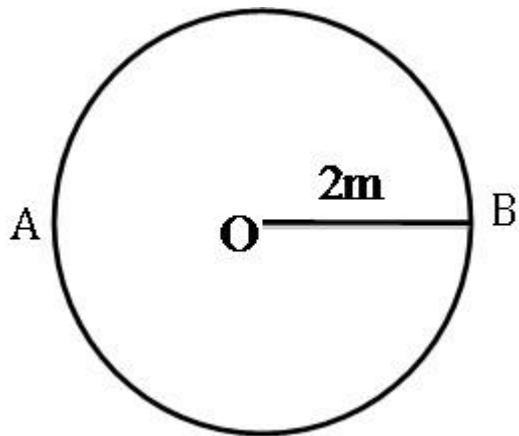C = k ----------- (3)

Using equation 3 in 2 we get
B = 2i - 3j
Thus, D is the correct answer option.

Question 2

Consider the figure given below. A man starts his journey from position A travels in a circle to position B, just opposite to A. What are values of displacement and distance? (OB is the radius)

A. 6.28 m and 4m
B. 4.28 m and 4 m
C. 4m and 6.28 m
D. 4 m and 4.28 m
E. 6.28 m and 4 m

Correct Answer: C

Explanation:

Displacement = Length (AB)
Length (AB) = OA + OB
Therefore, displacement = 4 m
Circumference of a circle is given as = 2πr ------------ (1)
Since, we need half of the circumference of the circle, dividing equation 1 by 2 we get distance travelled as
Distance = πr ------------ (2)
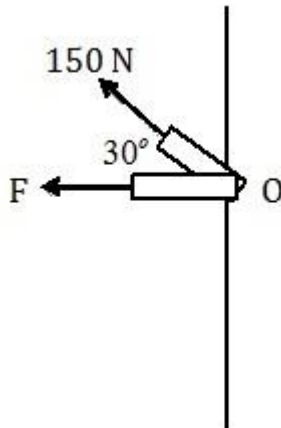Putting the value of r in equation 2 we get
Distance = 3.14 * 2
Or Distance = 6.28 m
Therefore, C is the correct answer option.

Question 3

Consider the figure given below. Two trusses are connected at common point O. What would be the force F required to keep the system in static equilibrium?

A. 129.9 N
B. -129.9 N
C. 134.6 N
D. -134.6 N
E. -125.6 N

Correct Answer: B

Explanation:

Since the forces are in equilibrium, we get

$\Sigma F_x = 0$ and $\Sigma F_y = 0$

Resolving the force (150 N) along x and y axis we get The orange arrow represents the vertical component of 150 N and the green arrow represents the horizontal component of 150 N. As the system of trusses is in equilibrium, equating the forces along x-axis we get

F + 150 cos 30° = 0 Or F = -129.9 N
The direction of force F is assumed to be towards the left of the screen as indicated in the figure. However, the negative sign signifies that the force is acting towards the right of the screen.

Hence, B is the correct answer option.

Question 4

The weight of a man is measured to be 600 N inside an elevator at rest. If his weight is measured inside the elevator when it is accelerating downwards, which of the following statements is true?

 A. Weight of the man will be more than measured before
 B. Weight of the man will be less than measured before
 C. There will be no change in the weight
 D. Weight of the man inside the elevator will be zero
 E. Not enough data is provided to predict the result

Correct Answer: B

Explanation:

In most of the cases normal reaction is same as the weight of any object. When the lift was at rest,

N = mg ------------ (1)

As the elevator is accelerating downwards with some value of acceleration, an unbalanced force is acting along the downward direction. So, we can write the equation of motion as

ma + mg = N Or mg = N - ma ---------- (2)

mg is the actual weight of the man. When the elevator was not accelerating down then, the weight of the man should be equal to the normal reaction. But, as the elevator accelerates down the actual weight is given by the difference between the normal reaction and. Thus, the weight of the man inside the elevator that is accelerating downwards will be less than the weight of the man measured when it was at rest. Therefore, B is the correct answer option.

Question 5

A disc rotating about its axis completes one complete rotation. What is the angle formed by the center of the disc with its radius after it completes one rotation?

 A. 180°
 B. 45°
 C. 90°
 D. 360°
 E. 720°

Correct Answer: D

Explanation:

A disc appears to be a circle when seen from above. Here OA is the radius of the disc or the circle. As the disc is rotating on its axis, we will assume any point, here A to be rotating along with the disc. If A moves to a point just opposite (B) to its initial point, center of the disc forms an angle of 1800 with the diameter BA.Again if the point B moves from its initial position to the position A (one complete

rotation), it forms an angle of π. Therefore, the total angle formed between the center and the radius OA for one complete rotation by the disc along its axis is 2π. Thus, D is the correct answer option.

Question 6

If a vehicle has twice the velocity of an identical (same mass) vehicle, what is the ratio of the kinetic energies between the faster moving vehicle and the slower moving vehicle?

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

Correct Answer: E

Explanation:

Let the kinetic energy of the slower and faster moving vehicles be

$KE_1 = (1/2)m_1v_1^2$ and $KE_2 = (1/2)m_2v_2^2$ respectively.

Dividing the equations, we get

$[KE_2 / KE_1] = [((1/2)m_2v_2^2) / ((1/2)m_1v_1^2)]$ ---------------- (4)

Since $m_1 = m_2$ and, $v_2 = 2 v_1$, equation 4 becomes

$[KE_2 / KE_1] = 4$
or $KE_2 : KE_1] = 4 : 1$

Thus, E is the correct answer option.

Question 7

A pendulum of unknown length is executing SHM with a time period of 2s. What is the length of the pendulum?

    A. 1.56 m
    B. 0.52 m
    C. 0.67 m
    D. 0.79 m
    E. 0.99 m

Correct Answer: E

Explanation:

Time period of pendulum is given as

$T = 2\pi \sqrt{l/g}$ --------------- (1)

Putting the values in equation 1 we get

$T = 2\pi \sqrt{l/9.8}$ Or $2 = \pi \sqrt{l/9.8}$ ---------------- (2)

Squaring both the sides of equation 2 we get

$4 = 4\pi r^2 * (l/9.8)$ Or $l = 0.99m$

Therefore, E is the correct answer option.

Question 8

Two boys are holding the ends of a string and one of them hits the string in such a way that waves start forming on the string. If it was observed that 4 troughs pass through a point in 10 seconds, what is the time period and frequency of the wave?

    A. 1.5 s and 0.1 s^{-1}
    B. 15 s and 1 s^{-1}
    C. 0.4 s and 2.5 s^{-1}
    D. 2.5 s and 0.4 s^{-1}
    E. 4 s and 0.25 s^{-1}

Correct Answer: D

Explanation:

Duration between consecutive troughs = Time period

Or, One oscillation = Time period -------------- (1)

Time taken to complete 4 oscillations = 10 s
Time taken to complete 1 oscillation = 2.5 seconds
Therefore, from equation 1 we can conclude that time period of the wave is 2.5 seconds. Frequency is related to time period as f = 1/T ------------- (2)

Putting the value in equation 2 we get
f = 1/2.5 Or f = 0.4 s^{-1} Therefore, D is the correct answer option.

Question 9

If a force of 1000 N is applied on a piston of surface area 100 cm^2, what is the pressure exerted on the surface area of the piston?

    A. 10^4 N
    B. 10^7 N
    C. 10^3 N
    D. 10^5 N
    E. 10^2 N

Correct Answer: D

Explanation:

Pressure exerted on the surface of the piston is given as

$P = F / A$ -------------- (1)

We are given area in cm^2 so we need to convert it into m^2.

Putting the values in equation 1 we get

$P = 1000 / 10^{-2}$ Or $P = 10^5$ N/m^2

Therefore, D is the correct answer option.

Question 10

What would be the change in entropy for 2 kg of a substance heated from 400 K to 500 K? (Specific heat of the substance = 3700 J/Kg K)

    A. 1634.4 J/K
    B. 1510.5 J/K
    C. 1200.9 J/K
    D. 1623.3 J/K
    E. 1644.4 J/K

Correct Answer: E

Explanation:

Theamount of heat transferredis given by $dQ = mc\Delta T$ ---------(1)

Change is temperature is given as $\Delta T = T_2 - T_1$--------- (2)

Putting the values in equation 2 we get $\Delta T = 100$ K
Therefore, $dQ = 740000$ J

According to second law of thermodynamics dS = dQ / T

Since T = [(T$_2$ + T$_1$) / 2], T = 450 K

Putting the values in equation 3 we get dS = 1644.4 J/K

Therefore, E is the correct answer option.

Question 11

A charged particle (10^{-9} C) of mass 10^{-5} kg is projected with a speed of 40 m/s. If the electric field of in the region is making the charged particle stop, what is the distance that the charged particle will travel before coming to rest?

A. 1 m
B. 1.5 m
C. 2.8 m
D. 4 m
E. 2 m

Correct Answer: E

Explanation:

Kinematic equation of motion is $v^2 = u^2 + 2as$ -------- (1)

Electric force experienced by the charged particle in the region is F = qE -------- (2)

Putting the values in equation 2 we get F = 4 x 10^{-3} N

Force due to motion of the charged particle is given as F = ma --------------- (3)

ma = 4 x 10^{-3}

10^{-5} x a = 4 x 10^{-3} Or a = 400 m/s^2

Putting the values in equation 1 we get
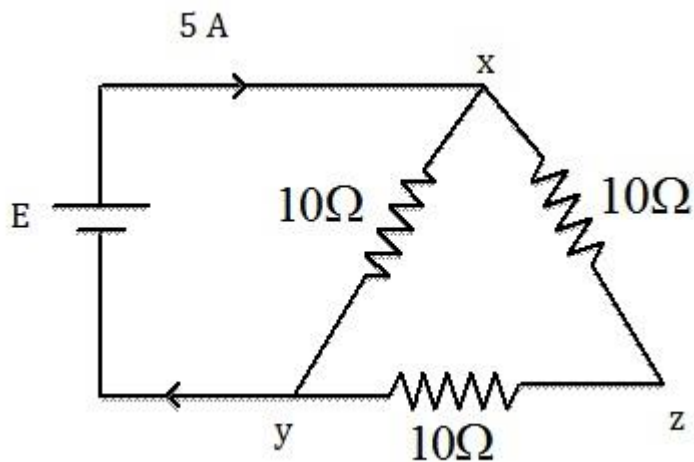
0 = 40^2 - 2 * 400 * S ------------- (4)

Negative sign is used because the charged particle is finally stopping i.e. charged particle is under retardation. Further solving equation 4 we get

2 * 400 * S = 40^2 Or S = 2m

Hence, E is the correct answer option.

Question 12

Consider the electrical circuit given below.

What is the value of E (source voltage), if the current flowing through the circuit as shown above is 5 A?

    A. 33.35 V
    B. 23.45 V
    C. 35.65 V
    D. 23.56 V
    E. 12.45 V

Correct Answer: A

Explanation:

Let the equivalent resistance of the series connection between the arms xz and zy be R_{eq1}. Therefore, $R_{eq1} = 20\Omega$

Now, R_{eq1} is in parallel with the resistance in the arm xy (10Ω).

Therefore, $R_{eq} = R_1 \,||\, R_2$

$R_{eq} = [(R_1 * R_2) / (R_1 + R_2)]$

Let the equivalent resistance of the parallel connection between 20Ω and 10Ω be R_{eq2}. Therefore,

$R_{eq2} = 20 \,||\, 10$ Or $R_{eq2} [(20 * 10) / (20 + 10)]$

R_{eq2} = 6.67 Ω

By Ohm's law E = IR Or E = 33.35 V

Therefore, A is the correct answer option.

Question 13

What is the dimensional formula for magnetic field?

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

Correct Answer: E

Explanation:

Force experienced by a charged particle in a magnetic field is given as
F = qvB sin θ
Or B = F / qv sin θ ----------- (1)

Dimensional formula of force is given as MLT^{-2} ------------- (2)

Dimensional formula of velocity becomes LT^{-1} ----------- (3)
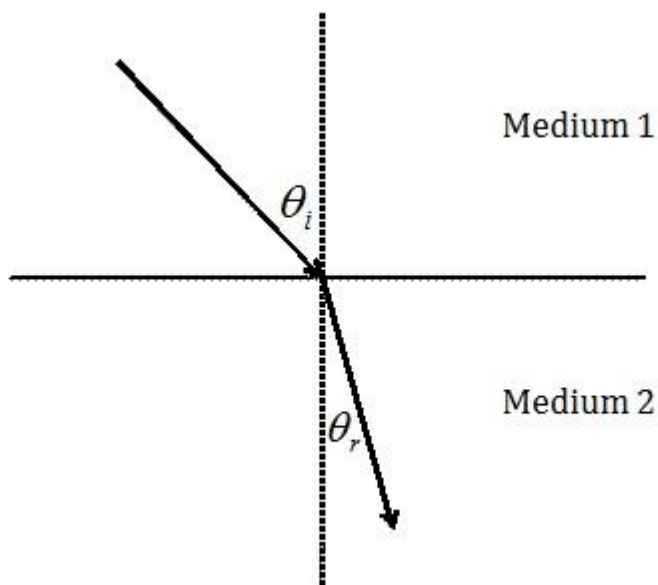
Charge is given as q = it -------------- (4)

Dimensional formula of q from equation 4 becomes AT ----------- (5)

Putting equations 2, 3 and 5 in 1 we get B = $MA^{-1}T^{-2}$

ThereforeE is the correct answer option.

Question 14

Consider the figure given below.

θ_i and θ_r are incident and refracted angles respectively. Which of the following is true for the refractive indices for medium 1 and medium 2? (Perpendicular dotted line represents normal to the interface)

    A. Refractive index of medium 1 is greater than the refractive index of medium 2
    B. Refractive index of medium 2 is higher than the refractive index of medium 1
    C. Refractive index of medium 1 is equal to the refractive index of medium 2
    D. Refractive index of medium 1 is zero
    E. Not enough data is provided to predict the answer

Correct Answer: B

Explanation:

The figure given in the question represents refraction of light. The bending of light is related to the refractive indices, when a ray of light is incident from medium 1 to medium 2 as follows

If the refractive index of medium 1 is lesser than the refractive index of medium 2, then the ray of light will bend towards the normal.

If the refractive index of medium 1 is greater than the refractive index of medium 2, then the ray of light will bend away from the normal.

It can be concluded from the above statements that the ray of light from medium 1 is bending towards the normal in medium 2. Hence B is the correct answer option.

Question 15

If the momentum of a photon is 2.5 x 10^{-25} kgms^{-1}, what is the frequency of the photon? (Planck's constant = 6.6 x 10^{-34} Js)

    A.   0.88 x 10^{17} Hz
    B.   1.14 x 10^{17} Hz
    C.   2.76 x 10^{17} Hz
    D.   3.5 x 10^{17} Hz
    E.   0.88 x 10^{15} Hz

Correct Answer: B

Explanation:

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

Momentum of a photon is p = mc --------------- (2)

Using equation 2 in 1 we get E = pc ------------ (3)

Energy of a photon is also expressed as --------------- (4)

Equating equation 4 and 3 we get,
hv = pc ----------- (5)

Putting the values in equation 5 we get

6.6 x 10^{-34} * v = 2.5 x 10^{-25} * 3 * 10^8

Or v = 1.14 x 10^{17} Hz

Hence, B is the correct answer option.