Work, Energy and Power JEE Main PYQ - 2

Total Time: 1 Hour : 15 Minute **Total Marks:** 120

Instructions

Instructions

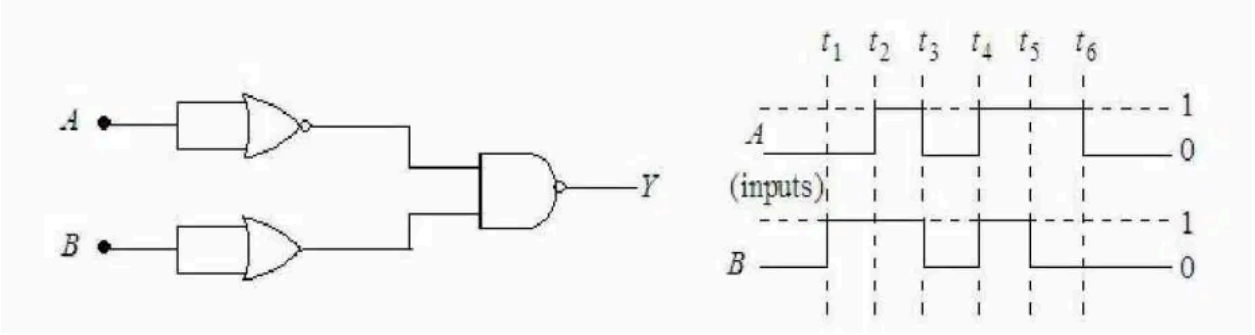
1. Test will auto submit when the Time is up.
2. The Test comprises of multiple choice questions (MCQ) with one or more correct answers.
3. The clock in the top right corner will display the remaining time available for you to complete the examination.

Navigating & Answering a Question

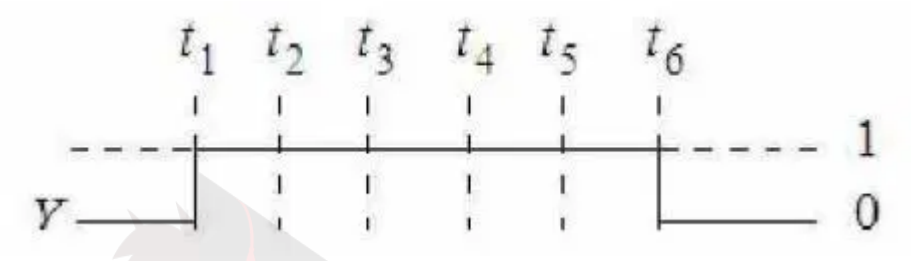
1. The answer will be saved automatically upon clicking on an option amongst the given choices of answer.
2. To deselect your chosen answer, click on the clear response button.
3. The marking scheme will be displayed for each question on the top right corner of the test window.

Work, Energy and Power

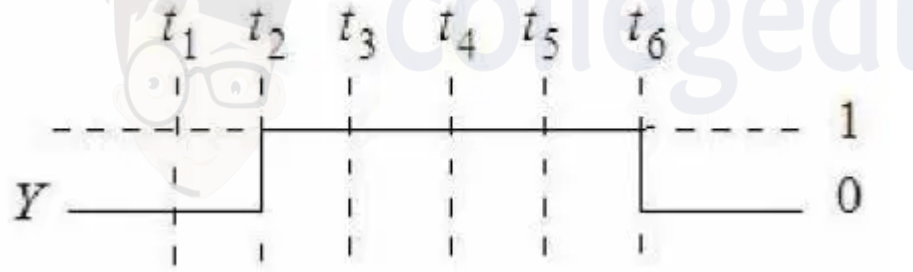
1. For the following circuit and given inputs A and B, choose the correct option for output 'Y' **(+4, -1)**



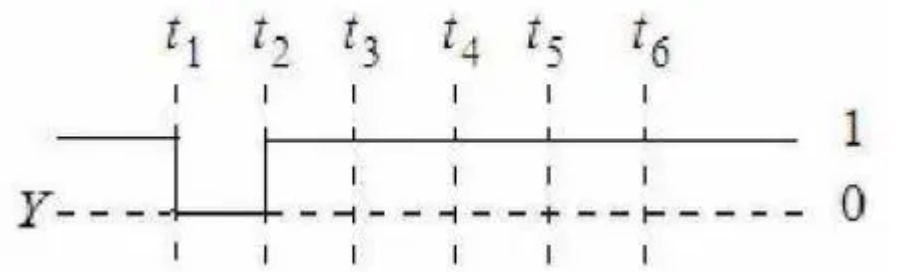
a.



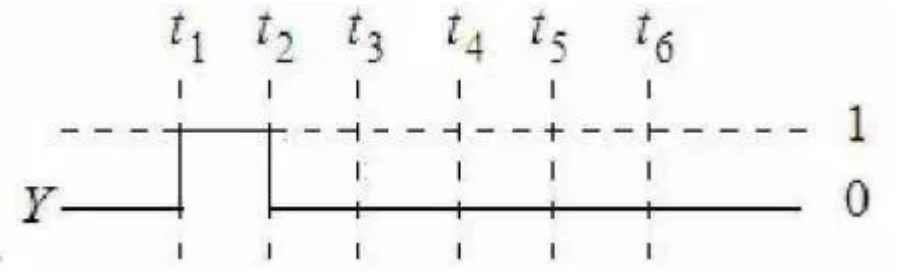
b.



c.



d.



2. Dimension of $\frac{1}{\mu_0 \in_0}$ should be equal to **(+4, -1)**

a. $\frac{L}{T}$

b. $\frac{T}{L}$

c. $\frac{L^2}{T^2}$

d. $\frac{T^2}{L^2}$

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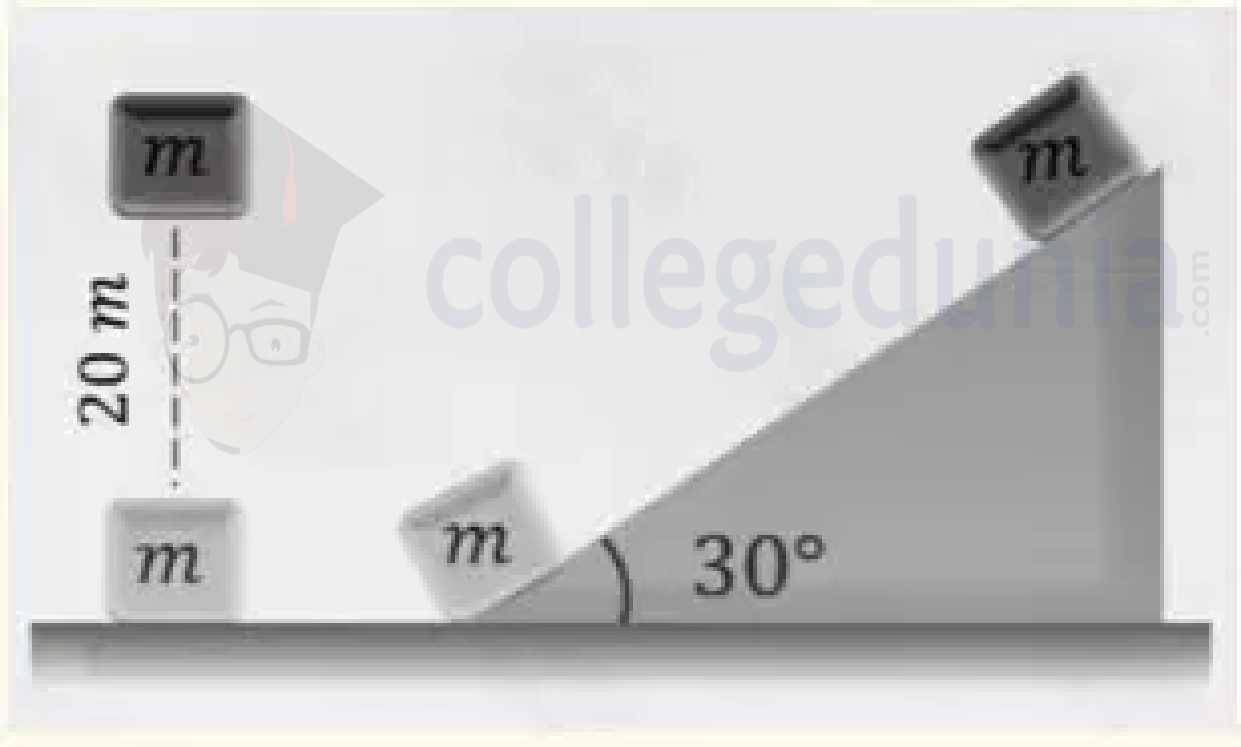
3. A block of mass m = 50 kg is lifted from ground to a height of 20 m in two different ways as shown in the figure. Find the ratio of work done by gravity in both the cases. **(+4, -1)**



a. 1 : 1

b. 1 : 2

c. 2 : 1

d. 1 : 5

---

4. A particle of mass 10 g moves in a straight line with retardation 2x, where x is the displacement in SI units. Its loss of kinetic energy for above displacement is **(+4, -1)**

$(10/x)^{-n}$ J. The value of n will be _____

---

5. **Assertion A:** If dQ and dW represent the heat supplied to the system and the work done on the system respectively, then according to the first law of thermodynamics: **(+4, -1)**

$$dQ = dU - dW.$$

Reason R: First law of thermodynamics is based on the law of conservation of energy.
In the light of the above statements, choose the correct answer from the options given below:

a. Both A and R are correct and R is the correct explanation of A

b. A is correct but R is not correct

c. A is not correct but R is correct

d. Both A and R are correct but R is not the correct explanation of A

---

6. Identify the correct statements from the following: **(+4, -1)**
A. Work done by a man in lifting a bucket out of a well by means of a rope tied to the bucket is negative.
B. Work done by gravitational force in lifting a bucket out of a well by a rope tied to the bucket is negative.
C. Work done by friction on a body sliding down an inclined plane is positive.
D. Work done by an applied force on a body moving on a rough horizontal plane with uniform velocity in zero.
E. Work done by the air resistance on an oscillating pendulum in negative.
Choose the correct answer from the options given below:

a. B, D and E only

b. A and C Only

c. *B* and *D* only

d. *B* and *E* only

7. Statement (1): A truck and a car moving with equal kinetic energy are stopped by equal retarding force. Both will cover equal distance to stop. Statement (2): A car moving towards east suddenly changes its direction towards north with same speed. Its acceleration is zero. In the light of given statements, choose the most appropriate answer from the options given below. **(+4, -1)**

a. Both (1) and (2) are true

b. Both (1) and (2) are false

c. (1) is true, (2) is false

d. (1) is false, (2) is true

8. Mass of body = 500 kg, μ= 0.7. Find work required to move a distance of 4 Km if the body moves with velocity 10 m/s. **(+4, -1)**

a. 3.5×10^6 J

b. 28×10^6 J

c. 7×10^6 J

d. 14×10^6 J

9. Water falls from a 40 m high dam at the rate of 9×10^4 kg per hour. Fifty percentage of gravitational potential energy can be converted into electrical energy. Using this hydro electric energy number of 100 W lamps, that can be lit, is : (Take g = 10 ms^{-2}) **(+4, -1)**

a. 25

b. 50

c. 100

d. 18

---

10. A block of mass *M* placed inside a box descends vertically with acceleration '*a*'.The block exerts a force equal to one-fourth of its weight on the floor of the box. **(+4, -1)**

The value of '*a*' will be

a. $\frac{g}{4}$

b. $\frac{g}{2}$

c. $\frac{3g}{4}$

d. g

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11. In the given figure, the block of mass *m* is dropped from the point '*A*'. The expression for kinetic energy of block when it reaches point '*B*' is **(+4, -1)**

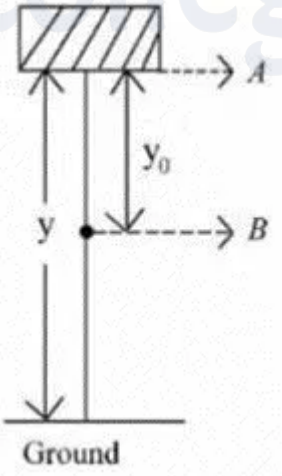


Fig.

a. $\frac{1}{2}mgy_0^2$

b. $\frac{1}{2}mgy^2$

c. $mg(y - y_0)$

d. mgy_0

12. A ball is projected vertically upward with an initial velocity of 50 ms^{-1} at t = 0 s. At t = 2 s, another ball is projected vertically upward with same velocity. At t = _____s, second ball will meet the first ball. (g = 10 ms^{-2}) **(+4, -1)**

13. A particle of mass m is moving in a circular path of constant radius r such that its centripetal acceleration (a) is varying with time t as $a = k^2rt^2$, where k is a constant. The power delivered to the particle by the force acting on it is given as **(+4, -1)**

a. Zero

b. $mk^2r^2t^2$

c. mk^2r^2t

d. mk^2rt

14. As per the given figure, two blocks each of mass $250\ g$ are connected to a spring of spring constant $2\ Nm^{-1}$. If both are given velocity v in opposite directions, then maximum elongation of the spring is: **(+4, -1)**

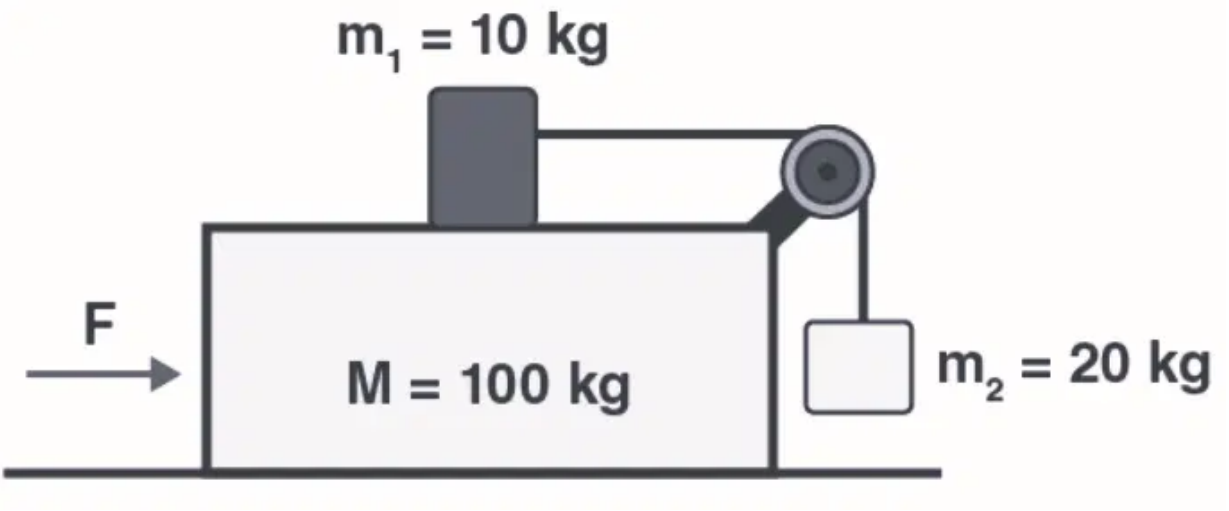
a. $\frac{v}{2\sqrt{2}}$

b. $\frac{v}{2}$

c. $\frac{v}{4}$

d. $\frac{v}{\sqrt{2}}$

15. Three masses M = 100 kg, m_1 = 10 kg and m_2 = 20 kg are arranged in a system as shown in figure. All the surfaces are frictionless and strings are inextensible and weightless. The pulleys are also weightless and frictionless. A force F is applied on the system so that the mass m_2 moves upward with an acceleration of 2 ms^{-2}. The value of F is (Take g = 10 ms^{-2}) **(+4, -1)**



a. 3360 N

b. 3380 N

c. 3120 N

d. 3240 N

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16. A boy ties a stone of mass 100 g to the end of a 2 m long string and whirls it around in a horizontal plane. The string can withstand the maximum tension of 80 N.If the maximum speed with which the stone can revolve is k/ π rev./min.The value of *K* is(Assume the string is massless and unstretchable) **(+4, -1)**

a. 400

b. 300

c. 600

d. 800

---

17. Three masses $M = 100\,kg, m_1 = 10\,kg$ and $m_2 = 20\,kg$ are arranged in a system as shown in figure All the surfaces are frictionless and strings are inextensible and weightless The pulleys are also weightless and frictionless A force F is applied on the system so that the mass m_2 moves upward with an acceleration of $2\,ms^{-2}$ The value of F is : (Take $g = 10\,ms^{-}2$) **(+4, -1)**

a. 3360 N

b. 3380 N

c. 3120 N

d. 3240 N

---

18. A body of mass $05\,kg$ travels on straight line path with velocity $v = (3x^2 + 4)\,m/s$ The net workdone by the force during its displacement from $x = 0$ to $x = 2\,m$ is : **(+4, -1)**

a. 64 J

b. 60 J

c. 120 J

d. 128 J

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19. Force acting on a particle moving along the x - axis is given by F = (2 + 3x)i. The work done by this force from x = 0 to x = 4 m is **(+4, -1)**

a. 16J

b. 32J

c. 4J

d. 8J

---

20. A variable force $F = 5x\ N$ acts on a body moving along x-axis. Find the work done by this force in displacing the body from $x = 2$ m to $x = 4$ m. (K is constant) **(+4, -1)**

a. $\left(\frac{205}{2}K\right)J$

b. $\left(\frac{105}{2}K\right)J$

c. $52KJ$

d. $51KJ$

---

21. Two bodies having the same linear momentum have a ratio of kinetic energy as 16:9. Find the ratio of masses of these bodies. **(+4, -1)**

a. $\frac{9}{16}$

b. $\frac{4}{3}$

c. $\frac{3}{4}$

d. $\frac{16}{9}$

---

22. A bag of sand of mass $98\,kg$ is suspended by a rope A bullet of $200\,g$ travelling with speed $10\,ms^{-1}$ gets embedded in it, then loss of kinetic energy will be **(+4, -1)**

a. $4.9J$

b. $9.8J$

c. $14.7J$

d. $19.6J$

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23. A body of mass $1\,\mathrm{kg}$ begins to move under the action of a time-dependent force **(+4, -1)**

$$\vec{F} = (t\,\hat{i} + 3t^2\,\hat{j})\,\mathrm{N},$$

where $\hat{i}$ and $\hat{j}$ are unit vectors along x and y axes. The power developed by the above force, at the time $t = 2\,\mathrm{s}$, will be _____ W.

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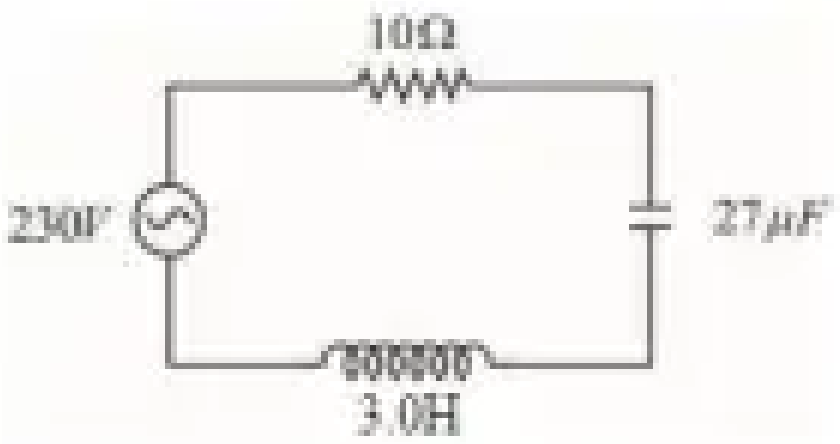
24. In the circuit shown in the figure, the ratio of the quality factor and the band width is__s **(+4, -1)**



25. In the circuit shown in the figure, the ratio of the quality factor and the band width is__s **(+4, -1)**

26. Vectors $a\hat{i}+b\hat{j}+\hat{k}$ and $2\hat{i}-3\hat{j}+4\hat{k}$ are perpendicular to each other when $3a+2b=7$, the ratio of a to b is $\frac{x}{2}$ The value of x is __ **(+4, -1)**

27. A spherical body of mass $2\,kg$ starting from rest acquires a kinetic energy of $10000\,J$ at the end of 5^{th} second The force acted on the body is ___N **(+4, -1)**

28. A body of mass $1kg$ collides head on elastically with a stationary body of mass $3kg$ After collision, the smaller body reverses its direction of motion and moves with a speed of $2m/s$ The initial speed of the smaller body before collision is ___ ms^{-1} **(+4, -1)**

29. **A ball is dropped from a height of $20m$ If the coefficient of restitution for the collision between ball and floor is 0.5, after hitting the floor, the ball rebounds to a height of ___m** **(+4, -1)**

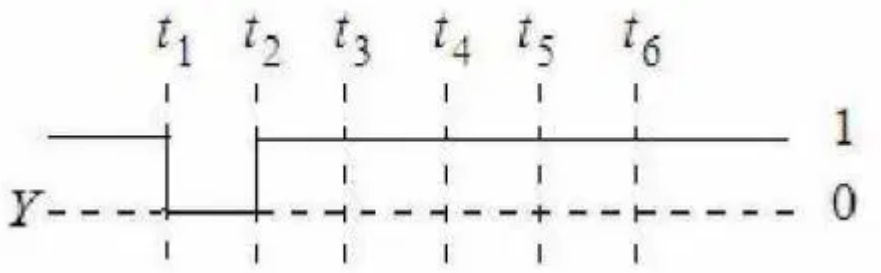
30. A small particle moves to position $5\hat{i}-2\hat{j}+\hat{k}$ from its initial position $2\hat{i}+3\hat{j}-4\hat{k}$ under the action of force $5\hat{i}+2\hat{j}+7\hat{k}N$. The value of work done will be ________J **(+4, -1)**

Answers

1. **Answer: c**

Explanation:

The correct option is: (C):



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2. **Answer: c**

Explanation:

Step 1: Use the relationship between μ_0, ϵ_0, and the speed of light.- Given $c = \frac{1}{\sqrt{\mu_0 \epsilon_0}}$, we know:

$\frac{1}{\mu_0 \epsilon_0} = c^2$.

Step 2: Analyze the dimensions.- Dimensional formula for c: $[c] = \frac{L}{T}$.- Hence, $[\frac{1}{\mu_0 \epsilon_0}] = [c^2] = \frac{L^2}{T^2}$.

Final Answer: The dimension is $\frac{L^2}{T^2}$

---

3. **Answer: a**

Explanation:

The Correct answer is option is (A) : 1 : 1

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4. **Answer: 2 - 2**

Explanation:

$$\text{Given, } a = -2x$$
$$\Rightarrow \frac{vdv}{dx} = -2x$$
$$\Rightarrow vdv = -2xdx$$
$$\Rightarrow \int_{v_1}^{v_2} vdv = -2\int_{0}^{x} xdx$$
$$\Rightarrow \frac{v_2^2}{2} - \frac{v_1^2}{2} = -\frac{2x^2}{2}$$
$$\Rightarrow \frac{mv_1^2}{2} - \frac{mv_2^2}{2} = mx^2 = \frac{10}{1000}x^2 = 10^{-2}x^2 = \left(\frac{10}{x}\right)^{-2}$$
$$\text{n} = 2.$$

---

5. Answer: a

Explanation:

- The first law of thermodynamics states:

$$\Delta Q = \Delta U + \Delta W.$$

- Rearranging gives:

$$dQ = dU - dW.$$

- This law is based on the conservation of energy.

Final Answer: $\boxed{(Option1)}$

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6. Answer: d

Explanation:

- (B) Work done by gravity is negative because the gravitational force opposes the upward motion.
- (E) Work done by air resistance is always negative because it opposes motion.
- **Other statements are incorrect because:**
- (A) Work done by a man is positive as the applied force is in the direction of

displacement.
- (C) Work done by friction is negative, not positive.
- (D) Work done is zero only if there is no displacement, not due to roughness.

Concepts:

1. Work, Energy and Power:

Work:

- Work is correlated to force and the displacement over which it acts. When an object is replaced parallel to the force's line of action, it is thought to be doing work. It is a force-driven action that includes movement in the force's direction.
- The work done by the force is described to be the product of the elements of the force in the direction of the displacement and the magnitude of this displacement.

Energy:

- A body's energy is its potential to do tasks. Anything that has the capability to work is said to have energy. The unit of energy is the same as the unit of work, i.e., the Joule.
- There are two types of mechanical energy such as; Kinetic and potential energy.

Read More: Work and Energy

Power:

- Power is the rate at which energy is transferred, conveyed, or converted or the rate of doing work. Technologically, it is the amount of work done per unit of time. The SI unit of power is Watt (W) which is joules per second (J/s). Sometimes the power of motor vehicles and other machines is demonstrated in terms of Horsepower (hp), which is roughly equal to 745.7 watts.
- Power is a scalar quantity, which gives us a quantity or amount of energy consumed per unit of time but with no manifestation of direction.

---

7. Answer: c

Explanation:

For (1) $v \propto \frac{1}{\sqrt{m}}$, $a \propto \frac{1}{m}$

$\because \quad s = \frac{v^2}{2a} \rightarrow$ independent of mass

For (2) direction is changed,

$\therefore a \neq 0$

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---

8. Answer: d

Explanation:

Since v = const. $\Rightarrow$ F = μmg = 0.7 × 500 × 10 = 3500 N

W = FS = $3.5 \times 10^3 \times 4 \times 10^3 = 14 \times 10^6$ J

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9. Answer: b

Explanation:

To determine the number of 100 W lamps that can be lit using the hydroelectric energy generated, we need to follow these steps:

1. **Calculate the gravitational potential energy:**
   - Given the height $h = 40\,\text{m}$, mass flow rate $\dot{m} = 9 \times 10^4\,\text{kg/h}$, and acceleration due to gravity $g = 10\,\text{m/s}^2$.
   - Convert the mass flow rate to kg/s: $\dot{m} = \frac{9 \times 10^4}{3600}\,\text{kg/s} \approx 25\,\text{kg/s}$.
   - The gravitational potential energy per second is given by: $P_{\text{gravitational}} = \dot{m} \times g \times h = 25 \times 10 \times 40 = 10000\,\text{J/s}$.
2. **Calculate the electrical energy output:**
   - Only 50% of the gravitational potential energy is converted to electrical energy, so $P_{\text{electrical}} = 0.5 \times 10000 = 5000\,\text{J/s}$.
3. **Determine the number of 100 W lamps:**
   - Since power is energy per unit time, and power is measured in watts (1 J/s = 1 W), the electrical power available is $5000\,\text{W}$.
   - Each lamp requires $100\,\text{W}$, so the number of lamps that can be lit is: $\frac{5000}{100} = 50$.

Thus, the number of 100 W lamps that can be lit is 50.

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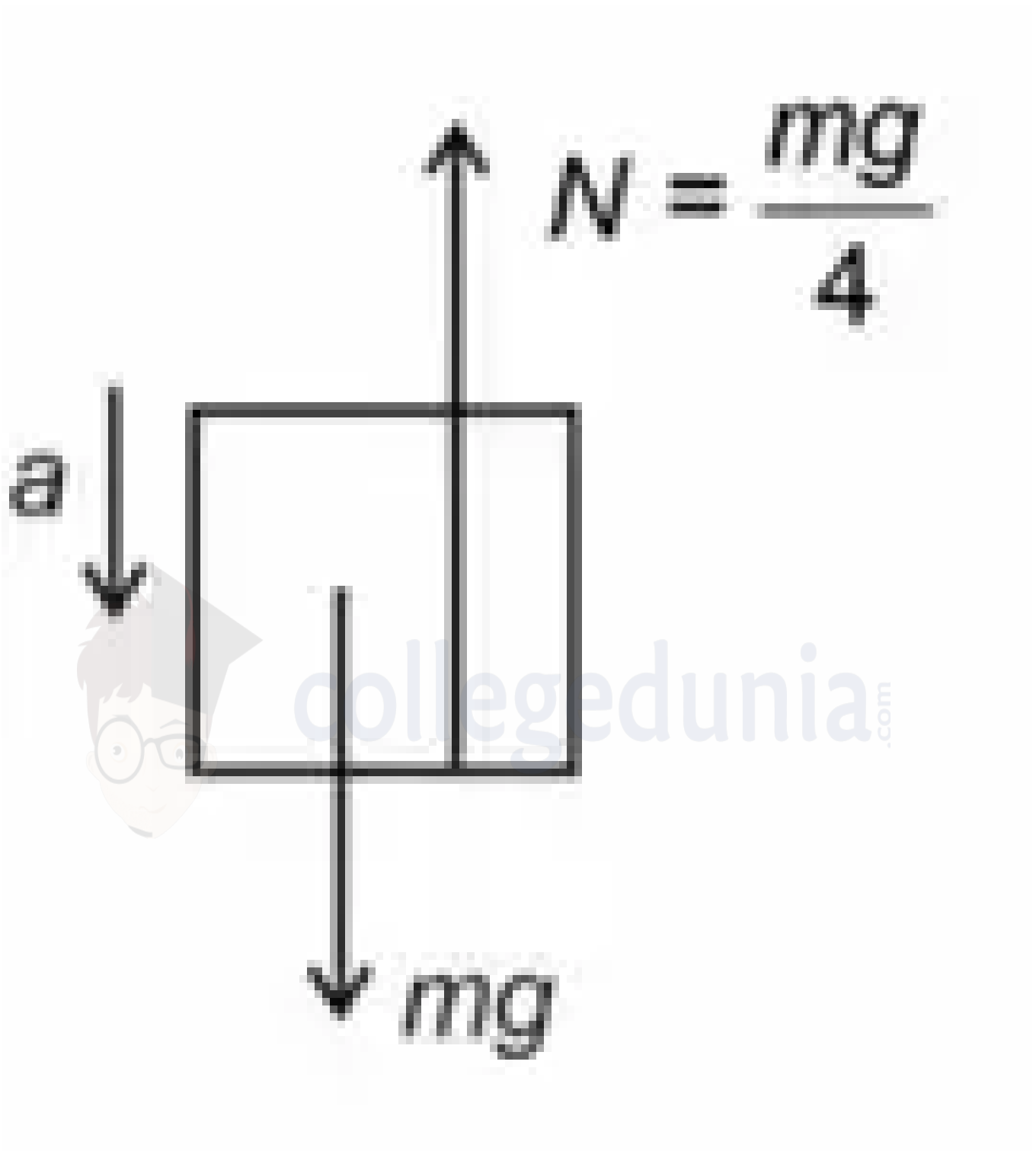
10. Answer: c

Explanation:

The correct answer is (C) : $\frac{3g}{4}$



By Using Newton's 2nd law , we get

$mg - \frac{mg}{4} = ma$

$\Rightarrow a = \frac{3g}{4}$

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11. Answer: d

Explanation:

The correct answer is (D) : mgy_0
Loss is potential energy = gain in kinetic energy
$-(mg(y - y_0) - mgy) = KE - 0$
$\Rightarrow KE = mgy_0$

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12. Answer: 6 - 6

Explanation:

The correct answer is : (6)
At t = 2 s, v_1 = 50 − 2 × 10 = 30 m/s

$v_2 = v_2$

$\therefore a_{rel} = g - g = 0$

$S = \frac{u^2 - v^2}{2g} = \frac{50^2 - 30^2}{2 \times 10} = \frac{1600}{20} = 80m$

$\therefore v_{rel} = 50 - 30 = 20m/s$

$\therefore \Delta t = \frac{80}{20} = 4s$

Therefore, Required time t = 2 + 4 = 6 s

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13. **Answer: c**

Explanation:

The correct answer is (C) : mk^2r^2t

$a_r = k^2rt^2 = \frac{v^2}{r}$

$\Rightarrow v^2 = k^2r^2t^2$ or $v = krt$

and

$\frac{d|v|}{dt} = kr$

$\Rightarrow a_t = kr$

$\Rightarrow |\vec{F} . \vec{v}| = (mkr)(krt)$

$= mk^2r^2t$ = power delivered

Concepts:

1. Work, Energy and Power:

Work:

- Work is correlated to force and the displacement over which it acts. When an object is replaced parallel to the force's line of action, it is thought to be doing work. It is a force-driven action that includes movement in the force's direction.
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- There are two types of mechanical energy such as; Kinetic and potential energy.

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- Power is a scalar quantity, which gives us a quantity or amount of energy consumed per unit of time but with no manifestation of direction.

---

14. Answer: b

Explanation:

$\because$ Loss in Kinetic Energy = Gain in spring energy

$\Rightarrow \frac{1}{2}mv^2 \times 2 = \frac{1}{2}kx_m^2$

$\Rightarrow 2 \times \frac{1}{4} \times v^2 = 2 \times x_m^2$

$\Rightarrow x_m = \sqrt{\frac{v^2}{4}}$

$\Rightarrow x_m = \frac{v}{2}$

So, the correct option is (B): $\frac{v}{2}$

Concepts:

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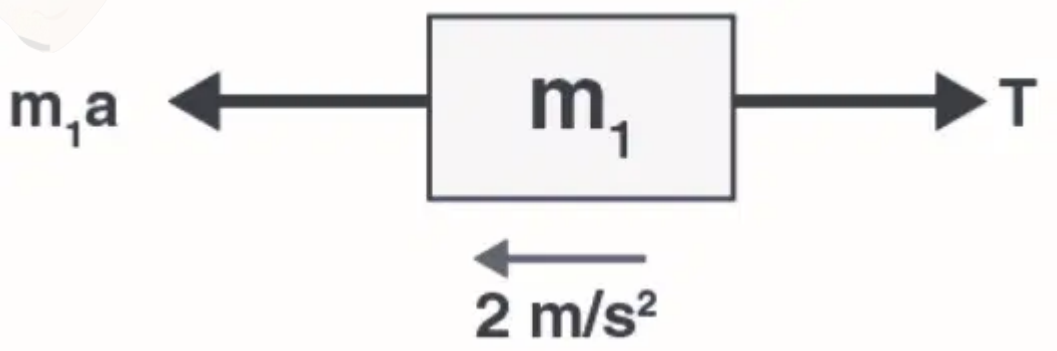
---

15. Answer: c

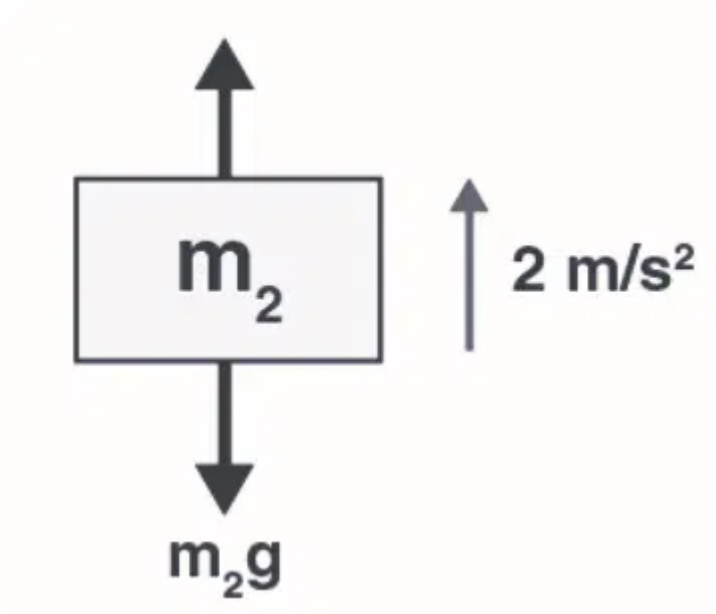
Explanation:

In frame of block of mass M moving with acceleration a.



$m_1a - T = 2m_1$

$10a - T = 20$ ...(i)



$T - m_2g = 2m_2$

$T - 200 = 40$

$T = 240$ ...(ii)

From equation 1 and 2

$10a = 260$

or, $a = 26\ m/s^2$

for block

$F = (M + m_2)a$

$F = 120 \times 26$

$F = 3120\ N$

So, the correct option is (C): 3120 N

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---

16. Answer: c

Explanation:

T=mw^2r

$\Rightarrow 80=0.1\times(2\pi\times\frac{K}{\pi}\times\frac{1}{60})^2\times 2$

$\Rightarrow \frac{800}{2}=\frac{K^2}{900}$

$\Rightarrow K = 30 \times 20 = 600$

The correct option is (C) : 600

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---

17. Answer: a

Explanation:

The value of F is 3360 N.
Therefore, the correct option is (A): 3360 N

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---

18. Answer: b

Explanation:

The correct option is (B) : 60 J

$v_i = 3(0)^2 + 4 = 4 \quad \cong x = 0$

$v_F = 3(2)^2 + 4 = 16 \quad \cong x = 2$

$W = \Delta K = \frac{1}{2}m(16^2 - 4^2)$

$= \frac{1}{2} \times \frac{1}{2}(256 - 16) = \frac{240}{4}$

$= 60\ J$

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---

19. Answer: b

Explanation:

The correct option is (B): 32J

Concepts:

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---

20. Answer: b

Explanation:

When force remains constant and motion occurs along a straight path, work is calculated as the product of force and distance traveled. However, when force varies within the distance traveled, calculus aids in resolving the problem by breaking it down into infinitesimal steps where force can be considered constant. Consequently, the work accomplished by a variable force is expressed as,

$W = \int F dx$

Here, the force is described by $F = 5x$ N, and the displacement ranges from $x = 2$ m to $x = 4$ m.

Now the work performed,

$W = \int F dx$

$W = \int 5x dx$

$W = 5 \int_2^4 x dx$

$W = 5[\frac{x^2}{2}]_2^4$

$W = \frac{5}{2}[4^2 - 2^2]$

$W = 5 \times 6$

$W = 30\ J$

So, the correct option is (B): $(\frac{105}{2} K)\ J$

Concepts:

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---

21. Answer: a

Explanation:

Let the masses of the two bodies be m_1 and m_2, and their velocities be v_1 and v_2 respectively.

Given:

$$\frac{\text{KE}_1}{\text{KE}_2} = \frac{16}{9}$$

$$\text{Momentum}_1 = \text{Momentum}_2 \implies m_1 v_1 = m_2 v_2$$

Step 1: Express Kinetic Energies

$$\text{KE}_1 = \frac{1}{2} m_1 v_1^2$$

$$\text{KE}_2 = \frac{1}{2} m_2 v_2^2$$

$$\frac{\text{KE}_1}{\text{KE}_2} = \frac{\frac{1}{2} m_1 v_1^2}{\frac{1}{2} m_2 v_2^2} = \frac{m_1 v_1^2}{m_2 v_2^2} = \frac{16}{9}$$

Step 2: Use Momentum Equality

$$m_1 v_1 = m_2 v_2 \implies v_2 = \frac{m_1}{m_2} v_1$$

Step 3: Substitute v_2 in the Kinetic Energy Ratio

$$\frac{m_1 v_1^2}{m_2 \left(\frac{m_1}{m_2} v_1\right)^2} = \frac{16}{9}$$

$$\frac{m_1 v_1^2}{m_2 \left(\frac{m_1^2}{m_2^2} v_1^2\right)} = \frac{16}{9}$$

$$\frac{m_1}{m_2} \cdot \frac{m_2^2}{m_1^2} = \frac{16}{9}$$

$$\frac{m_2}{m_1} = \frac{16}{9}$$

$$\frac{m_1}{m_2} = \frac{9}{16}$$

Step 4: Determine the Ratio of Masses

$$\text{Ratio of masses} = m_1 : m_2 = 9 : 16$$

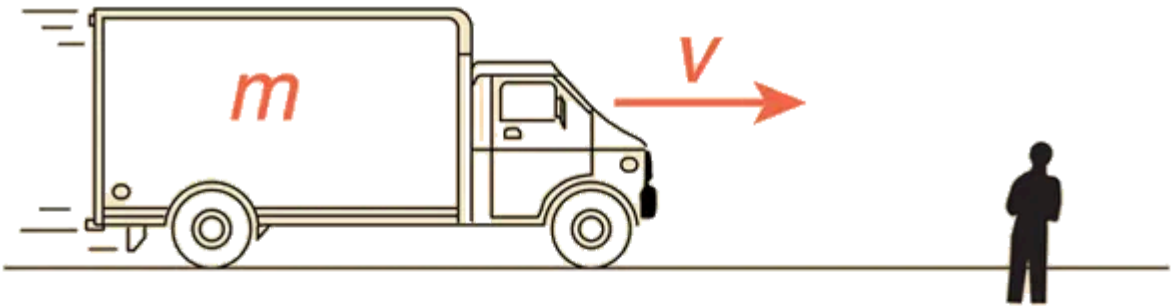
Hence, the correct ratio of their masses is $9 : 16$.

Concepts:

1. Kinetic energy:

Kinetic energy of an object is the measure of the work it does as a result of its motion. Kinetic energy is the type of energy that an object or particle has as a result of its movement. When an object is subjected to a net force, it accelerates and gains kinetic energy as a result. Kinetic energy is a property of a moving object or particle defined by both its mass and its velocity. Any combination of motions is possible, including translation (moving along a route from one spot to another), rotation around an axis, vibration, and any combination of motions.

Kinetic Energy = $\frac{1}{2}mv^2$



You know it's not a good idea to step out into the road right now because of the truck's kinetic energy. It can do work on you as a result of this "motion energy".

You know intuitively that the KE depends upon the speed of the truck. A faster truck can do more work on you.

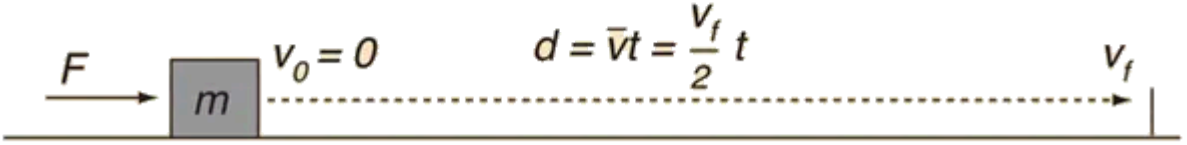
The KE depends upon the square of the velocity! So at twice the speed, the truck has 4 x the energy! Why does it increase by the square?

$$KE = \frac{1}{2}mv^2$$

Where does the factor 1/2 come from?

You know intuitively that the KE depends upon the mass of the truck. A more massive truck could do more work on you.

The kinetic energy of an object arises from the net work done on it. This can be seen from the example of using a constant net force to accelerate a mass from rest to a final velocity.



$$a = \frac{F}{m} = \frac{v_f}{t} \quad \text{in the absence of friction}$$

$$\text{Work done on mass} = Fd = mad = m\frac{v_f}{t}\frac{v_f}{2}t = \frac{1}{2}mv_f^2 = \text{kinetic energy}$$

---

22. **Answer: b**

Explanation:

$P_i = P_f$ (no any external force)
$0.2 \times 10 = 10 \times v$
$v = 0.2\, m/sec$
Loss in K.E. $= \frac{1}{2} \times (0.2) \times 10^2 - \frac{1}{2} \times 10(0.2)^2$
$= \frac{1}{2} \times 10 \times (0.2)[10 - 0.2]$
$= 9.8\, J$

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---

23. Answer: 100 - 100

Explanation:

The force acting on the body is:

$$\vec{F} = t\,\hat{i} + 3t^2\,\hat{j}$$

The acceleration is given by Newton's second law:

$$\vec{a} = \frac{\vec{F}}{m} = \vec{F} \quad (\text{since } m = 1\,\text{kg})$$

The velocity is obtained by integrating acceleration:

$$\vec{v} = \int \vec{a}\,dt = \int (t\,\hat{i} + 3t^2\,\hat{j})\,dt = \frac{t^2}{2}\,\hat{i} + t^3\,\hat{j}$$

At $t = 2\,\text{s}$:

$$\vec{v} = \frac{2^2}{2}\,\hat{i} + 2^3\,\hat{j} = 2\,\hat{i} + 8\,\hat{j}$$

The power is given by:

$$P = \vec{F} \cdot \vec{v}$$

Substitute $\vec{F} = 2\,\hat{i} + 3 \cdot 2^2\,\hat{j} = 2\,\hat{i} + 12\,\hat{j}$ and $\vec{v} = 2\,\hat{i} + 8\,\hat{j}$:

$$P = (2\,\hat{i} + 12\,\hat{j}) \cdot (2\,\hat{i} + 8\,\hat{j}) = (2 \cdot 2) + (12 \cdot 8) = 4 + 96 = 100\,\text{W}$$

Thus, the power at $t = 2\,\text{s}$ is $100\,\text{W}$.

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24. Answer: 10 - 10

Explanation:

The relations for an LCR circuit are:

$$\Delta\omega = \frac{R}{L}, \quad Q = \frac{\omega_0}{\Delta\omega} = \omega_0 \cdot \frac{L}{R}.$$

The resonant angular frequency ω_0 is given by:

$$\omega_0 = \frac{1}{\sqrt{LC}} = \frac{1}{\sqrt{3 \times 27 \times 10^{-6}}} = \frac{1}{9 \times 10^{-3}}.$$

Simplify:

$$\omega_0 = 10^3 \, \text{rad/s}.$$

The ratio $\frac{Q}{\Delta\omega}$ is:

$$\frac{Q}{\Delta\omega} = \frac{\omega_0 \cdot L/R}{R/L} = \omega_0 \cdot \frac{L^2}{R^2}.$$

Substituting the values:

$$\frac{Q}{\Delta\omega} = \sqrt{\frac{1}{LC}} \cdot \frac{L^2}{R^2}.$$

Simplify further:

$$\frac{Q}{\Delta\omega} = \frac{1}{9 \times 10^{-3}} \cdot \frac{9}{100} = 10 \, \text{s}.$$

Thus, the ratio of the quality factor to the bandwidth is:

$$\boxed{10 \, \text{s}}.$$

Concepts:

1. Ray Optics and Optical Instruments:

Optics, deals with the determination of behaviour and the properties of light, along with its interactions with the matter and also with the instruments that are used to detect it.

Ray optics is also known as the geometrical optics and it is a branch of science which describes light propagation.

Reflection is the change in direction of light at an interface in-between two different media so that the wave-front returns into a medium from which it was originated.

Speed of light is the rate at which the light travels in free space.

A phenomenal change in image formed when the light is passed from one medium to another which is called Refraction.

Total Internal Reflection is the reflection of light when the light ray enters into a rarer medium from a denser medium and the angle of incidence is higher than the

critical angle of incidence then that light ray will be reflected back to the denser medium.

Read More: Ray Optics and Optical Instruments

---

25. Answer: 0 - 0

Explanation:

The correct answer is 10.

$\Delta\omega = \frac{R}{L}$

$Q = \frac{\omega_0}{\Delta\omega} = \omega_0 \frac{L}{R}$

$\omega_0 = \frac{1}{\sqrt{3\times27\times10^{-6}}} = \frac{1}{9\times10^{-3}}$

$\frac{Q}{\Delta\omega} = \frac{\omega_0 \frac{R}{R}}{\frac{R}{L}} = \omega_0 \frac{L^2}{R^2} = \sqrt{\frac{1}{LC}} \frac{L^2}{R^2}$

$= \frac{1}{9\times10^{-3}} \times \frac{9}{100} = 10\ s$

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---

26. Answer: 1 - 1

Explanation:

For two vectors to be perpendicular, their dot product must be zero:

$$\vec{a} \cdot \vec{b} = 0.$$

Substitute $\vec{a} = a\hat{i} + b\hat{j} + \hat{k}$ and $\vec{b} = 2\hat{i} - 3\hat{j} + 4\hat{k}$:

$$(a\hat{i} + b\hat{j} + \hat{k}) \cdot (2\hat{i} - 3\hat{j} + 4\hat{k}) = 0.$$

Simplify:

$$2a - 3b + 4 = 0.$$

This gives the first equation:

$$2a - 3b = -4.$$

From the problem, another equation is given:

$$3a + 2b = 7.$$

Solve the simultaneous equations: Multiply equation (1) by 2:

$$4a - 6b = -8.$$

Multiply equation (2) by 3:

$$9a + 6b = 21.$$

Add equations (3) and (4):

$$13a = 13 \quad \Rightarrow \quad a = 1.$$

Substitute $a = 1$ into equation (2):

$$3(1) + 2b = 7 \quad \Rightarrow \quad 3 + 2b = 7 \quad \Rightarrow \quad 2b = 4 \quad \Rightarrow \quad b = 2.$$

The ratio of a to b is:

$$\frac{a}{b} = \frac{x}{2} \quad \Rightarrow \quad \frac{1}{2} = \frac{x}{2}.$$

Thus:

$$x = 1.$$

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---

27. Answer: 40 - 40

Explanation:

The kinetic energy is related to velocity as:

$$\frac{1}{2}mv^2 = \text{KE}$$

Substitute the given values ($m = 2\,\text{kg}$, $\text{KE} = 10000\,\text{J}$):

$$\frac{1}{2} \cdot 2 \cdot v^2 = 10000$$

$$v^2 = 10000, \quad v = 100\,\text{m/s}$$

The acceleration is found using:

$$v = u + at$$

Since the body starts from rest ($u = 0$) and reaches $v = 100\,\text{m/s}$ in $t = 5\,\text{s}$:

$$100 = 0 + a \cdot 5 \implies a = \frac{100}{5} = 20\,\text{m/s}^2$$

The force acting on the body is:

$$F = m \cdot a = 2 \cdot 20 = 40\,\text{N}$$

Concepts:

1. Work, Energy and Power:

Work:

- Work is correlated to force and the displacement over which it acts. When an object is replaced parallel to the force's line of action, it is thought to be doing work. It is a force-driven action that includes movement in the force's direction.
- The work done by the force is described to be the product of the elements of the force in the direction of the displacement and the magnitude of this displacement.

Energy:

- A body's energy is its potential to do tasks. Anything that has the capability to work is said to have energy. The unit of energy is the same as the unit of work, i.e., the Joule.

- There are two types of mechanical energy such as; Kinetic and potential energy.

Read More: Work and Energy

Power:

- Power is the rate at which energy is transferred, conveyed, or converted or the rate of doing work. Technologically, it is the amount of work done per unit of time. The SI unit of power is Watt (W) which is joules per second (J/s). Sometimes the power of motor vehicles and other machines is demonstrated in terms of Horsepower (hp), which is roughly equal to 745.7 watts.
- Power is a scalar quantity, which gives us a quantity or amount of energy consumed per unit of time but with no manifestation of direction.

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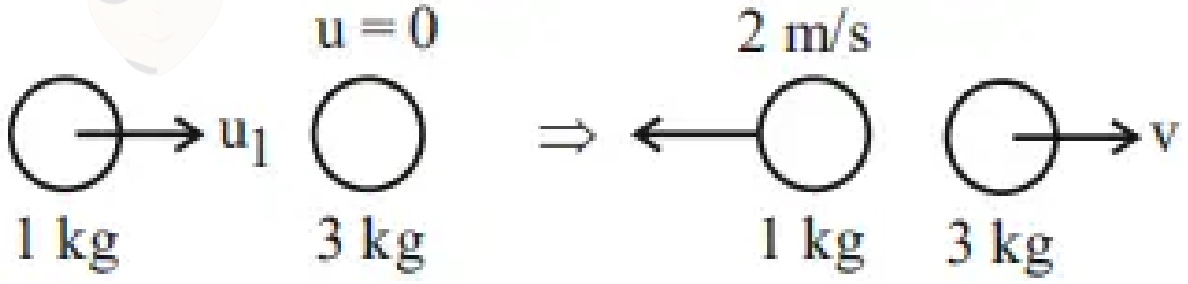
28. Answer: 4 - 4

Explanation:

The correct answer is 4.



$$1 \times u_1 = -2 + 3v \quad \Rightarrow \quad u_1 = -2 + 3v \quad \ldots\ldots (1)$$

$$1 = \frac{v+2}{u_1} \quad \Rightarrow \quad v + 2 = u_1 \quad \ldots\ldots (2)$$

Solving (1) and (2)

$$u_1 = 4 \text{ m/s}$$

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29. Answer: 5 - 5

Explanation:

The height to which the ball rebounds is given by:

$$h' = e^2 \times h$$

where e is the coefficient of restitution and h is the initial height. Substituting the values:

$$h' = (0.5)^2 \times 20 = 0.25 \times 20 = 5\,\text{m}$$

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30. **Answer: 40 - 40**

Explanation:

$W = \vec{F}.(\vec{r_f} - \vec{r_i})$

$= (5\hat{i} + 2\hat{j} + 7\hat{k}).((5\hat{i} - 2\hat{j} + \hat{k}) - (2\hat{i} + 2\hat{j} - 4\hat{k}))$

$W = 40J$

So, The correct answer is 40.

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