PHYS141 OUTLINE QUESTIONS SOLUTIONS

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Exercise 5a

Chapter 7, Page 147

Principles of Physics, International Edition
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Solutions Verified

Solution A   Solution B

Answered 1 year ago

Step 1 1 of 3

First, we have that the kinetic energy of the father K_f is half the kinetic energy of the son K_s , and the mass of son m_s is half the mass of the father m_f:

$K_f = \frac{1}{2}K_s$

$m_s = \frac{1}{2}m_f$

Equation for kinetic energy in general is:

$$K = \frac{mv^2}{2}$$

v_f and v_s are speeds of father and son, respectively.
When we apply it to our problem, it gives:

$$\frac{m_f v_f^2}{2} = \frac{1}{2}\frac{m_s v_s^2}{2}$$

$$m_f v_f^2 = \frac{1}{2}m_s v_s^2$$

Since mass of the father is two times the mass of the son:

$$m_f v_f^2 = \frac{1}{2}\frac{1}{2}m_s v_s^2$$

And finally:

$$v_f^2 = \frac{v_s^2}{4}$$

Step 2 2 of 3

After the father speeds, his kinetic energy is equal to the kinetic energy of the son:

$$v_{f2} = v_f + 1m/s$$

$$\frac{m_f(v_f+1)^2}{2} = \frac{m_s v_s^2}{2}$$

$$m_f(v_f+1)^2 = m_s v_s^2$$

Since mass of the father is two times the mass of the son:

$$m_f(v_f+1)^2 = \frac{m_f v_s^2}{2}$$

$$(v_f+1)^2 = \frac{v_s^2}{2}$$

When we use the previous equation for v_s and v_f, we get:

$$v_f^2 = \frac{v_s^2}{4}$$

$$v_s^2 = 4v_f^2$$

$$(v_f+1)^2 = 2v_f^2$$

$$v_f^2 + 2v_f + 1 = 2v_f^2$$

$$v_f^2 - 2v_f - 1 = 0$$

$$v_f = \frac{2 \pm \sqrt{4+4}}{2}$$

$$v_f = \frac{2 \pm 2\sqrt{2}}{2}$$

$$v_f = 1 \pm \sqrt{2}$$

Speeds of the father and son are in the same direction, so we take a positive solution:
And finally, the original speed of a father is:

$$v_f = 2.41m/s$$

Result 3 of 3

Father: $v_f = 2.41m/s$

Rate this solution

‹ Exercise 4b   Exercise 5b ›

Exercise 5b

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Solution Verified Answered 1 year ago

Step 1 1 of 2

For the son's original speed we have

$$v_s^2 = 4v_f^2$$

so

$$v_s^2 = 4 \cdot 2.41^2 m^2/s^2 = 23.23 m^2/s^2$$

$$v_s = 4.82 m/s$$

Result 2 of 2

Son: $v_s = 4.82 m/s$

Exercise 5a Rate this solution Exercise 6

Exercise 8

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Solution Verified Answered 2 years ago

Step 1 1 of 2

In order to solve this problem we will use the fact that the work is defined as a dot product of the force and the displacement vector

$$W = \vec{F} \cdot \vec{x} = \sum_i F_i x^i$$

If we apply this to the vectors given in the problem we have that

$$W = (210\hat{\imath} - 150\hat{\jmath}) \cdot (20\hat{\imath} - 16\hat{\jmath}) = 210 \times 20 + 150 \times 16$$

Which gives that the work done by the water is

$$W = 6.6 \times 10^3 \mathrm{J}$$

Result 2 of 2

$$W = 6.6 \times 10^3 \mathrm{J}$$

Rate this solution

Exercise 7 Exercise 9

Exercise 9

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Solution Verified Answered 2 years ago

Step 1 1 of 4

Givens:

Mass of the canister, m = 2 kg.

Magnitude of the force, F (The force is moving in x-y plane) = 5 N.

Initial velocity of the canister, v_i = $4\hat{i}$ m/s.

Final velocity of the canister, v_f= $6\hat{j}$ m/s.

Step 2 2 of 4

The change in the kinetic energy of the canister equals the net work done on the canister (**Kinetic energy and work energy theorem**).

$$\Delta K = W_{\text{net}} \tag{1}$$
$$K_f - K_i = W_{\text{net}} \tag{2}$$

$$\text{Initial kinetic energy} = K_i = \frac{1}{2}mv_i^2 = \frac{1}{2} \times 2 \times (\sqrt{4^2 + 0^2 + 0^2})^2 = 16 \text{ m/s.}$$
$$\text{Final kinetic energy} = K_f = \frac{1}{2}mv_f^2 = \frac{1}{2} \times 2 \times (\sqrt{0^2 + 6^2 + 0^2})^2 = 36 \text{ m/s.}$$

Substitute in equation 2:

$$\begin{aligned}\text{Work done on the canister by the 5 N force (the only existing force)} &= 36 - 16 \\ &= 20 \text{ J.}\end{aligned}$$

Step 3 3 of 4

Comment:

To find the magnitude of a vector $\vec{V} = V_x\hat{i} + V_y\hat{j} + V_z\hat{k}$, then

$$\left|\vec{V}\right| = \sqrt{V_x^2 + V_y^2 + V_z^2}$$

Result 4 of 4

$$W = 20 \text{ J}$$

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Solution Verified Answered 2 years ago

Step 1

1 of 2

In order to solve this problem we will use the fact that the work is defined as a dot product of the force and the displacement vector

$$W = \vec{F} \cdot \vec{x} = \sum_i F_i x^i = |F||x| \cos\theta$$

and it is equal to the change in the kinetic energy of a system, ΔK. Our displacement vector is given as

$$\vec{x} = 5\hat{\imath} - 3\hat{\jmath} + 4\hat{k}$$

Let's find it's magnitude using the well known formula

$$|x| = \sqrt{5^2 + 3^2 + 4^2} = \sqrt{50}$$

$$|x| = 7.07\text{m}$$

Now, we can use the first relation to express the angle

$$\Delta K = |F||x| \cos\theta$$

$$\cos\theta = \frac{\Delta K}{|F||x|}$$

a) Now in the case when $\Delta K = 45$J we have

$$\cos\theta = \frac{45}{22 \times 7.07}$$

$$\theta = 73^\circ$$

b) Whereas in the case when $\Delta K = -45$J

$$\cos\theta = \frac{-45}{22 \times 7.07}$$

$$\theta = 107^\circ$$

Result

2 of 2

$$\text{a) } \theta = 73^\circ$$

$$\text{b) } \theta = 107^\circ$$

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Solution Verified Answered 2 years ago

Step 1 1 of 2

To solve this problem, we will first have to determine the force acting on the survivor by the helicopter and by the gravity. Let's do it first for the latter

$$F_g = -mg = -75 \times 9.8 = -735\text{N}$$

The force by the helicopter is to be found from Newton's second law

$$ma = F - mg$$

but we know that $a = g/10$

$$F = \frac{mg}{10} + mg = \frac{11}{10}mg$$

$$F = 808.5\text{N}$$

a) Now, the work done by the helicopter is given as

$$W_h = Fd = 808.5 \times 16$$

$$W_h = 13 \times 10^3\text{J}$$

b) And the work done by the gravity is

$$W_g = -F_g d = -735 \times 16$$

$$W_g = -12 \times 10^3\text{J}$$

c) The kinetic energy of the survivor is going to be equal to the sum of work done by the helicopter and by the gravity

$$K = W_g + W_h = -11.76 \times 10^3 + 12.94 \times 10^3$$

$$K = 1.2 \times 10^3\text{J}$$

d) The speed of the survivor at the moment of reaching the helicopter can be found from

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

which can be solved for v to have

$$v^2 = \frac{2K}{m} = \frac{2 \times 1.18 \times 10^3}{75}$$

Which finally gives that

$$v = 5.6\text{m/s}$$

Result 2 of 2

$$\text{a) } W_h = 13 \times 10^3\text{J}$$

$$\text{b) } W_g = -12 \times 10^3\text{J}$$

$$\text{c) } K = 1.2 \times 10^3\text{J}$$

$$\text{d) } v = 5.6\text{m/s}$$

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Solution Verified Answered 2 years ago

Step 1 1 of 2

To solve this problem we will simply deduce the initial spring energy from its final energy

$$W_s = -\frac{1}{2}kx_f^2 + \frac{1}{2}kx_i^2$$

which becomes

$$W_s = \frac{1}{2}k(x_i^2 - x_f^2) = 0.5 \times 5 \times 10^3 \times (5^2 - 10^2) \times 10^{-4}$$

Finally, we have that

$$W_s = 18.8\text{J}$$

Result 2 of 2

$$W_s = 18.8\text{J}$$

Exercise 25b
Rate this solution
Exercise 27a

Exercise 35a

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Solution Verified Answered 1 year ago

Step 1 1 of 3

Givens:

Force applied on a particle along x-axis, $F = F_o(\frac{x_o}{x} - 1)$.

Initial position of the particle $x_o = 0$, and its final position $x_f = 2x_o$.

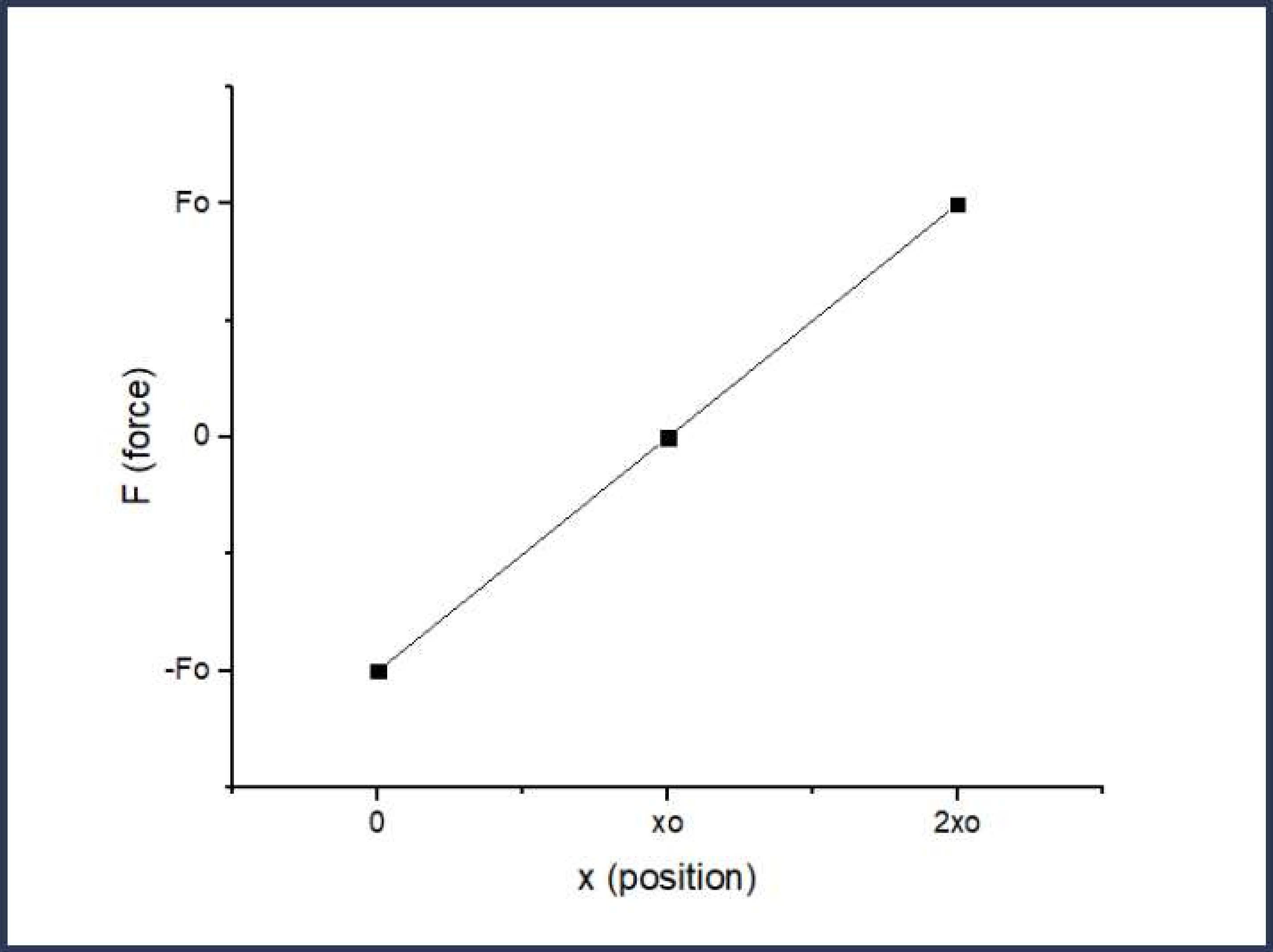
Step 2 2 of 3

Part a :

To get the work done on the particle by the applied force, calculate the area under the curve (See below).

Area under the curve = area of the triangle = $\frac{1}{2}$ Base of the triangle $\times$ its Height

$$\text{Work done on the particle} = W = \frac{1}{2}(2x_o - 0) \times (F_o - F_o) = 0 \text{ J}.$$



Result 3 of 3

(a) $W = 0$ J

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Step 1 1 of 2

Part b :

The work done on the particle by the force is also given by the following integral:

$$W=\int_{r_i}^{r_f}\vec{F}\cdot d\vec{r}=\int_{r_i}^{r_f}(F_x\hat{i}+F_y\hat{j}+F_z\hat{k})\cdot(dx\hat{i}+dy\hat{j}+dz\hat{k})$$
$$=\int_{x_i}^{x_f}F_x\,dx+0+0=\int_0^{2x_o}F_o(\frac{x}{x_o}-1)\,dx$$
$$=F_o\int_0^{2x_o}(\frac{x}{x_o}-1)\,dx=F_o[\frac{x^2}{2x_o}-x]\Big|_0^{2x_o}$$

Substitute with the upper and lower limits of the integral :

$$W=F_o\Big(\frac{(2x_o)^2}{2xo}-2x_o\Big)-F_o\Big(\frac{(0)^2}{2xo}-0\Big)=0-0=0\text{ J.}$$

Result 2 of 2

(b) $W=0$ J

Exercise 35a Rate this solution Exercise 36

Exercise 37a

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Step 1 1 of 4

Givens:

Mass of the particle $m = 2$ kg.

$a_s = 6\ \mathrm{m/s^2}$

Applied force on the particle is $\vec{F}_a$

Initial position of the particle $x_o = 0$ m.

Final position of the particle $x_f = 9$ m.

Step 2 2 of 4

The Work done on the particle by the force $\vec{F}_a$ is given by the following integral, noting that the particle is moving along the x-axis:

$$W_{\text{total}} = \int_{x_i}^{x_f} \vec{F}_a \cdot d\vec{x} \qquad (1)$$

And from Newton's second law of motion, the force applied to the particle can be expressed as the multiplication of the particle mass by its acceleration.

$$\vec{F}_a = m\vec{a} \qquad (2)$$

Where $\vec{a}$ is the particle acceleration.

Substituting equation 2 into equation 1 gives:

$$\begin{aligned} W_{\text{total}} &= \int_{x_i}^{x_f} m\vec{a} \cdot d\vec{x} = m \int_{x_i}^{x_f} \vec{a} \cdot d\vec{x} \\ &= m \times \text{Area under the curve (Figure 7.40).} \end{aligned}$$

Step 3 3 of 4

Part a :

The work done on the particle by the force from $x = 0$ m to $x = 4$ m is the summation of:

1- work done from $x = 0$ m to $x = 1$ m.

2- work done from $x = 1$ m to $x = 4$ m.

$$\begin{aligned} W_{x=0\to4} &= W_{x=0\to1} + W_{x=1\to4} \\ &= m(\text{area of the triangle } + \text{area of the rectangular}) \\ &= 2 \times (\frac{1}{2} \times (1-0) \times (6-0) + (4-1) \times (6-0)) = 42\ \text{J.} \end{aligned}$$

Result 4 of 4

(a) $W = 42$ J

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Step 1 1 of 2

Part b :

The work done on the particle by the force from $x = 0$ m to $x = 7$ m is the summation of:

1- work calculated in part (a).

2- work done from $x = 4$ m to $x = 5$ m.

3- work done from $x = 5$ m to $x = 6$ m.

4- work done from $x = 6$ m to $x = 7$ m.

$$W_{x=0\to7} = W_{x=0\to4} + W_{x=4\to5} + W_{x=5\to6} + W_{x=6\to7}$$
$$\text{It can be seen that;}$$
$$W_{x=4\to5}, \text{ and } W_{x=5\to6}$$
$$\text{are equal but with opposite signs.}$$
$$\text{Then, } W_{x=4\to5} + W_{x=5\to6} = 0 \text{ J.}$$

$$\therefore W_{x=0\to7} = W_{x=0\to4} + W_{x=6\to7} = 42 + m \times (\text{area of the rectangle})$$
$$= 42 + 2 \times (7-6) \times (-6-0) = 30 \text{ J.}$$

Result 2 of 2

(b) $W = 30$ J

Exercise 37a Rate this solution Exercise 37c

Exercise 37c

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Step 1 1 of 2

Part c :

The work done on the particle by the force from $x=0$ m to $x=9$ m is the summation of:

1- work calculated in section (b).

2- work done from $x=7\ \mathrm{m}$ to $x=8\ \mathrm{m}$.

3- work done from $x=8\ \mathrm{m}$ to $x=9\ \mathrm{m}$.

$$\begin{aligned}W_{x=0\to9} &= W_{x=0\to7}+W_{x=7\to8}+W_{x=8\to9}\\&=30+m\times(\text{area of the rectangular}+\text{area of the triangle})\\&=30+2\times\left((8-7)\times(-6-0)+\frac{1}{2}\times(9-8)\times(-6-0)\right)=12\ \mathrm{J}.\end{aligned}$$

The change in the kinetic energy of the particle equals the net work done on it (Kinetic energy and work energy theorem).

$$\begin{aligned}\Delta K &= W_{\text{net}}\\K_f-K_i &= W_{\text{net}}\end{aligned}\tag{3}$$

Result 2 of 2

(c) $W=12\ \mathrm{J}$

Exercise 37d

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Solution Verified Answered 1 year ago

Step 1 1 of 2

Part d :

To get the velocity of the particle when it reaches $x = 4$ m, we substitute in equation 3.

$$K_f - K_i = W_{x=0 \to 4}$$
$$\frac{1}{2} m v_{x=4}^2 - 0 = 42$$

Where m is the mass of the particle, and $v_{x=4}$ is the speed of the particle when it reaches a distance of 4 m.

<u>**Note**</u> : $K_i = 0$ J, because the particle starts from rest (Figure 7.40).

$$0.5 \times 2 \times v_{x=4}^2 = 42$$
$$\therefore\ v_{x=4} = \sqrt{\frac{42}{0.5 \times 2}} = 6.48 \text{ m/s}.$$

Therefore, the speed of the particle at $x = 4$ m is 6.48 m/s and directed along the positive $x-$axis (From figure 7.40).

Result 2 of 2

(d) $v = 6.48$ m/s

Exercise 37e

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Solution Verified Answered 1 year ago

Step 1 1 of 2

Part e :

To get the velocity of the particle when it reaches $x = 7\ \mathrm{m}$, we substitute in equation 3.

$$K_f - K_i = W_{x=0\to 7}$$
$$\frac{1}{2}mv_{x=7}^2 - 0 = 30$$

Where m is the mass of the particle, and $v_{x=7}$ is the speed of the particle when it reaches a distance of $7\ \mathrm{m}$.

$\underline{\textbf{Note}}$: $K_i = 0\ \mathrm{J}$, because the particle starts from rest (Figure 7.40).

$$0.5 \times 2 \times v_{x=7}^2 = 30$$
$$\therefore\ v_{x=7} = \sqrt{\frac{30}{0.5 \times 2}} = 5.48\ \mathrm{m/s}.$$

Therefore, the speed of the particle at $x = 7\ \mathrm{m}$ is $5.48\ \mathrm{m/s}$ and directed along the positive $x-$axis (From figure 7.40).

Result 2 of 2

(e) $v = 5.48\ \mathrm{m/s}$

Exercise 37f

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Solution Verified Answered 1 year ago

Step 1 1 of 2

Part f :

To get the velocity of the particle when it reaches $x = 9$ m, substitute in equation 3.

$$K_f - K_i = W_{x=0\to 9}$$
$$\frac{1}{2}mv_{x=9}^2 - 0 = 12$$

Where m is the mass of the particle, and $v_{x=9}$ is the speed of the particle when it reaches a distance of 9 m.

<u>**Note**</u> : $K_i = 0$ J, because the particle starts from rest (Figure 7.40).

$$0.5 \times 2 \times v_{x=9}^2 = 30$$
$$\therefore\ v_{x=9} = \sqrt{\frac{12}{0.5 \times 2}} = 3.46 \text{ m/s}.$$

Therefore, the speed of the particle at $x = 9$ m is 3.46 m/s and directed along the positive $x-$axis (From figure 7.40).

Result 2 of 2

(f) $v = 3.46$ m/s

Exercise 37e Rate this solution Exercise 38

Exercise 41

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Solution Verified Answered 2 years ago

Step 1

To solve this problem, we will exploit the fact that the work done by a force is given as

$$W = \int F dx$$

However, we do not know the form of the force and we do not know x-axis limits so we will have to improvise. Let's first find the force. We know that

$$F = ma = m\frac{d^2x}{dt^2}$$

so let's find the second derivative of the position function x

$$x = 4t - 5t^2 + 2t^3$$

$$\frac{d^2x}{dt^2} = -10 + 12t$$

So, the force is now given as

$$F = m(-10 + 12t)$$

Now, let's express the differential dx via dt

$$dx = (4 - 10t + 6t^2)dt$$

Now, our work integral becomes

$$W = \int F dx = m\int_0^6 (-10 + 12t)(4 - 10t + 6t^2)dt$$

$$W = m\int_0^6 (-40 + 148t - 180t^2 + 72t^3)dt$$

After the integration, we obtain the following

$$W = m(-40t + 74t^2 - 180t^3 + 72t^4)|_0^6 = 2.8 \times (40 \times 6 + 74 \times 6^2 - 180 \times 6^3 + 72 \times 6^4)$$

Finnally the work done by the force is given as

$$W = 13 \times 10^3 \mathrm{J}$$

Result

$$W = 13 \times 10^3 \mathrm{J}$$

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Solution Verified Answered 2 years ago

Step 1 1 of 2

To solve this problem we are going the use the fact that the change in the kinetic energy corresponds to the work performed on the system, i.e. it has to hold that

$$\Delta K = W = \int F dx$$

The force performing the work here is the x-component of the tension T given as

$$F = F\cos\theta$$

where θ is the angle formed by the cord and the horizontal. This angle is not a constant and it depends on the position of the block as

$$\cos\theta = \frac{x}{\sqrt{x^2+h^2}}$$

Now, the introductory integral can be written as

$$\Delta K = T\int_{x_1}^{x_2} \frac{x}{\sqrt{x^2+y^2}}(-dx)$$

Please note that we have a minus sign since we integrate towards the negative side but we can invert the integration and get

$$\Delta K = T\int_{x_2}^{x_1} \frac{x}{\sqrt{x^2+y^2}}dx$$

This integral can be solved by introducing the variable $u = x^2 + h^2$ which gives us that

$$\Delta K = T\sqrt{x^2+h^2}|_{x_2}^{x_1} = T \times (\sqrt{x_1^2+h^2} - \sqrt{x_2^2+h^2})$$

$$\Delta K = 28 \times (\sqrt{3^2+1.25^2} - \sqrt{1^2+1.25^2})$$

We finally obtain that the change in the kinetic energy is given as

$$\Delta K = 105\text{J}$$

Result 2 of 2

$$\Delta K = 105\text{J}$$

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Solution Verified Answered 2 years ago

Step 1 1 of 2

In order to solve this problem, we have to understand that we can get the rate of work, i.e. power if we know what distance does the block cover in one second. This is known since by definition the power is given as

$$P = F \cdot v$$

On, the other hand the force is given as $F = mg$ and it is colinear with the speed which is given as $v = \Delta x / \Delta t$ so we can write that

$$P = \frac{mg\Delta x}{\Delta t} = \frac{5 \times 10^3 \times 9.8 \times 210}{23}$$

Finally, we have that

$$P = 450 \times 10^3 \mathrm{W}$$

Result 2 of 2

$$P = 450 \times 10^3 \mathrm{W}$$

Exercise 45 Rate this solution Exercise 47a