#16 Kinetic Energy Post-class

Due: 11:00am on Friday, September 28, 2012

Note: You will receive no credit for late submissions. To learn more, read your instructor's Grading Policy

Exercise 6.6

Two tugboats pull a disabled supertanker. Each tug exerts a constant force of $1.3 \times 10^6 \mathrm{N}$, one an angle 13° west of north and the other an angle 13° east of north, as they pull the tanker a distance 0.90 km toward the north.

Part A

What is the total work they do on the supertanker?

Express your answer using two significant figures.

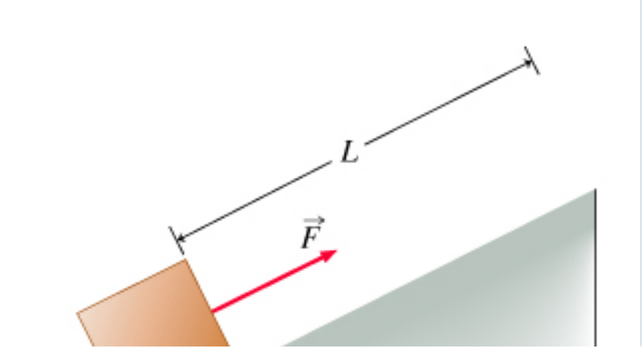
ANSWER:

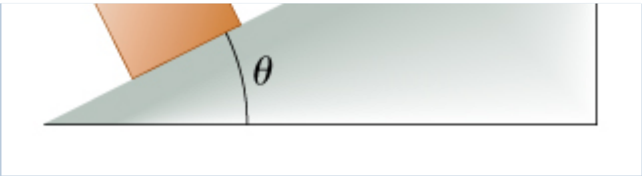
W = 2.3×10^9 J

Correct

Pulling a Block on an Incline with Friction

A block of weight mg sits on an inclined plane as shown. A force of magnitude F is applied to pull the block up the incline at constant speed. The coefficient of kinetic friction between the plane and the block is μ.





Part A

What is the total work $W_{\rm fric}$ done on the block by the force of friction as the block moves a distance L up the incline?

Express the work done by friction in terms of any or all of the variables μ, m, g, θ, L, and F.

Hint 1. How to start

Draw a free-body force diagram showing all real forces acting on the block.

Hint 2. Find the magnitude of the friction force

Write an expression for the magnitude $F_{\rm fric}$ of the friction force.

Express your answer in terms of any or all of the variables μ, m, g, and θ.

Hint 1. Find the magnitude of the normal force

What is the magnitude N of the normal force?

Express your answer in terms of m, g, and θ.

ANSWER:

$N = mg\cos(\theta)$

ANSWER:

F_{fric} = $\mu mg\cos(\theta)$

ANSWER:

W_{fric} = $-mg\cos\theta\mu L$

Correct

Part B

What is the total work W_F done on the block by the applied force $\vec{F}$ as the block moves a distance L up the incline?

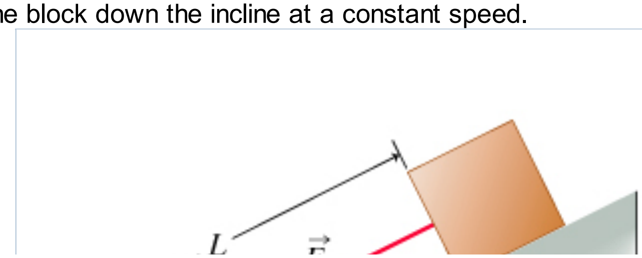
Express your answer in terms of any or all of the variables μ, m, g, θ, L, and F.

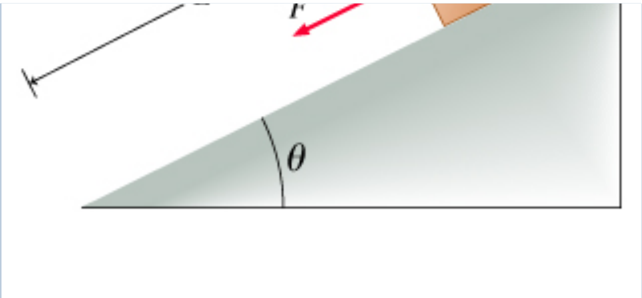
ANSWER:

W_F = $mg\sin\theta L + mg\cos\theta\mu L$

Correct

Now the applied force is changed so that instead of pulling the block up the incline, the force pulls the block down the incline at a constant speed.





Part C

What is the total work $W_{\rm fric}$ done on the block by the force of friction as the block moves a distance L down the incline?

Express your answer in terms of any or all of the variables μ, m, g, θ, L, and F.

ANSWER:

$W_{\rm fric}$ = $-mg\cos\theta\mu L$

Correct

Part D

What is the total work W_F done on the box by the appled force in this case?

Express your answer in terms of any or all of the variables μ, m, g, θ, L, and F.

ANSWER:

W_F = $-mg\sin\theta L+mg\cos\theta\mu L$

Correct

Work-Energy Theorem Reviewed

Learning Goal:

Review the work-energy theorem and apply it to a simple problem.

If you push a particle of mass M in the direction in which it is already moving, you expect the particle's speed to increase. If you push with a constant force F, then the particle will accelerate with acceleration $a = F/M$ (from Newton's 2nd law).

Part A

Enter a one- or two-word answer that correctly completes the following statement.

If the constant force is applied for a fixed interval of time t, then the _____ of the particle will increase by an amount at.

Hint 1. Kinematic equations recalled

Recall the kinematic equations -

$v = u + at$;

$s = ut + \frac{1}{2}at^2$;

$v^2 = u^2 + 2as$.

ANSWER:

velocity

Correct

Part B

Enter a one- or two-word answer that correctly completes the following statement.

If the constant force is applied over a given distance D, along the path of the particle, then the _____ of the particle will increase by FD.

ANSWER:

kinetic energy

Correct

The work W done on the particle by the force F over the distance D is FD.

Part C

If the initial kinetic energy of the particle is $K_{\rm i}$, and its final kinetic energy is $K_{\rm f}$, express $K_{\rm f}$ in terms of $K_{\rm i}$ and the work W done on the particle.

ANSWER:

$K_{\rm f}$ = $K_{\rm i}+W$

Correct

This is the work-energy theorem, often written $W = K_{\rm f} - K_{\rm i}$. It is, essentially, a statement of energy conservation that does not include potential energy explicitly. All forces--even conservative forces like gravity--contribute to the work.

Part D

In general, the work done by a force $\vec{F}$ is written as

$$W = \int_{\mathrm{i}}^{\mathrm{f}} \vec{F}(\vec{r}) \cdot d\vec{r}\,.$$

Now, consider whether the following statements are true or false:

- The dot product assures that the integrand is always nonnegative.
- The dot product indicates that only the component of the force perpendicular to the path contributes to the integral.
- The dot product indicates that only the component of the force parallel to the path contributes to the integral.

Enter t for true or f for false for each statement. Separate your responses with commas (e.g., t,f,t).

ANSWER:

f,f,t

Correct

Part E

Assume that the particle has initial speed v_{i}. Find its final kinetic energy K_{f} in terms of v_{i}, M, F, and D.

Hint 1. Find the initial kinetic energy

Express the initial kinetic energy K_{i} in terms of the particle's initial velocity v_{i} and its mass M.

ANSWER:

K_{i} = $.5Mv_{\mathrm{i}}^2$

ANSWER:

K_{f} = $\frac{1}{2}Mv_{\mathrm{i}}^2 + FD$

Correct

Part F

What is the final speed of the particle?

Express your answer in terms of K_f and M.

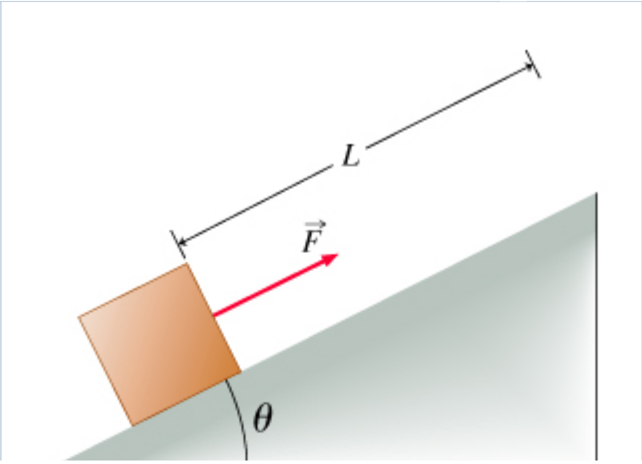
ANSWER:

v_f = $\sqrt{\frac{2K_f}{M}}$

Correct

Work on a Sliding Block

A block of weight w sits on a frictionless inclined plane, which makes an angle θ with respect to the horizontal, as shown. A force of magnitude F, applied parallel to the incline, pulls the block up the plane *at constant speed*.



Part A

The block moves a distance L up the incline. The block does not stop after moving this distance but continues to move with constant speed. What is the total work $W_{\rm tot}$ done on the block by all forces? (Include only the work done after the block has started moving, not the work needed to start the block moving from rest.)

Express your answer in terms of given quantities.

Hint 1. What physical principle to use

To find the total work done on the block, use the work-energy theorem:

$$W_{\rm tot} = K_{\rm f} - K_{\rm i}.$$

Hint 2. Find the change in kinetic energy

What is the change in the kinetic energy of the block, from the moment it starts moving until it has been pulled a distance L? Remember that the block is pulled at constant speed.

Hint 1. Consider kinetic energy

If the block's speed does not change, its kinetic energy cannot change.

ANSWER:

$K_{\rm f} - K_{\rm i}$ = 0

ANSWER:

W_{tot} = 0

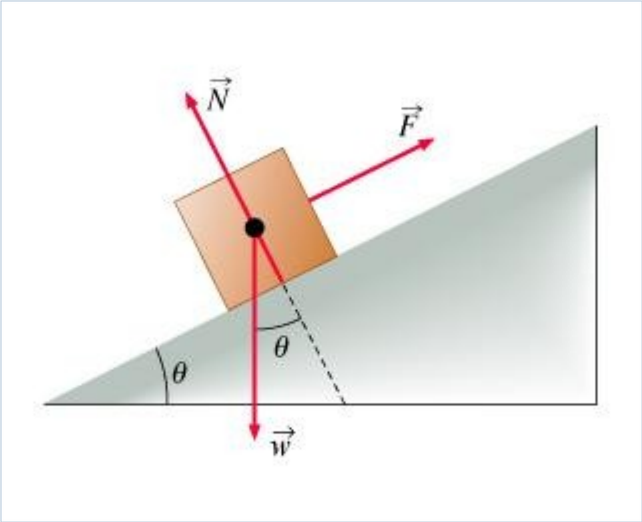
Correct

Part B

What is W_g, the work done on the block by the force of gravity as the block moves a distance L up the incline?

Express the work done by gravity in terms of the weight w and any other quantities given in the problem introduction.

Hint 1. Force diagram



Hint 2. Force of gravity component

What is the component of the force of gravity in the direction of the block's displacement (along the inclined plane)?

Express your answer in terms of w and θ.

Hint 1. Relative direction of the force and the motion

Remember that the force of gravity acts *down* the plane, whereas the block's displacement is directed *up* the plane.

ANSWER:

$F_{g||}$ = $-w\sin(\theta)$

ANSWER:

W_g = $-w\sin\theta L$

Correct

Part C

What is W_F, the work done on the block by the applied force F as the block moves a distance L up the incline?

Express your answer in terms of F and other given quantities.

Hint 1. How to find the work done by a constant force

Remember that the work done on an object by a particular force is the integral of the dot product of the force and the instantaneous displacement of the object, over the path followed by the object. In this case, since the force is constant and the path is a straight segment of length L up the inclined plane, the dot product becomes simple multiplication.

ANSWER:

W_F = FL

Correct

Part D

What is $W_{\rm normal}$, the work done on the block by the normal force as the block moves a distance L up the inclined plane?

Express your answer in terms of given quantities.

Hint 1. First step in computing the work

The work done by the normal force is equal to the dot product of the force vector and the block's displacement vector. The normal force and the block's displacement vector are perpendicular. Therefore, what is their dot product?

ANSWER:

$\vec{N}\cdot\vec{L}$ = 0

ANSWER:

W_{normal} = 0

Correct

Score Summary:

Your score on this assignment is 100.1%.
You received 40.04 out of a possible total of 40 points.