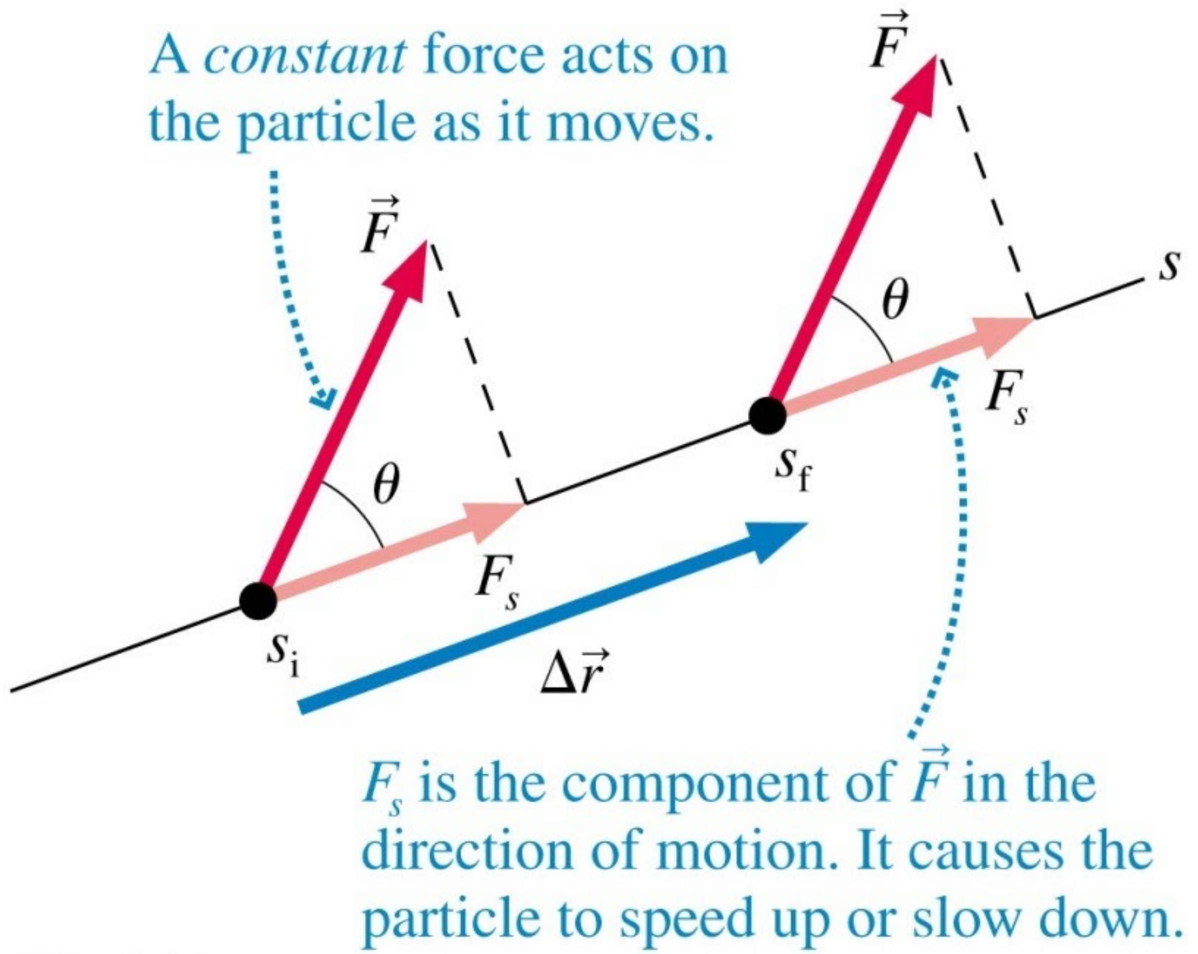
The Work-Kinetic Energy theorem

$$\Delta K = W_{\text{net}}$$

Work-kinetic energy theorem: When one or more forces act on a particle as it is displaced from an initial position to a final position, the net work done on the particle by these forces causes the particles kinetic energy to change by:

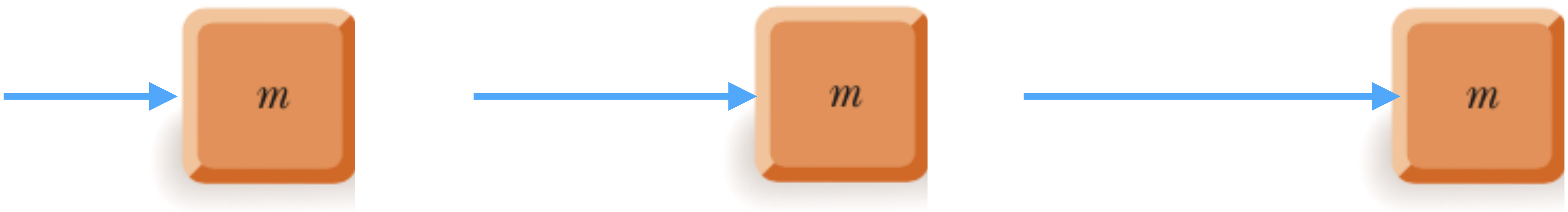
Work Done by a Constant Force

$$W = \vec{F} \cdot \Delta\vec{r}$$



Work

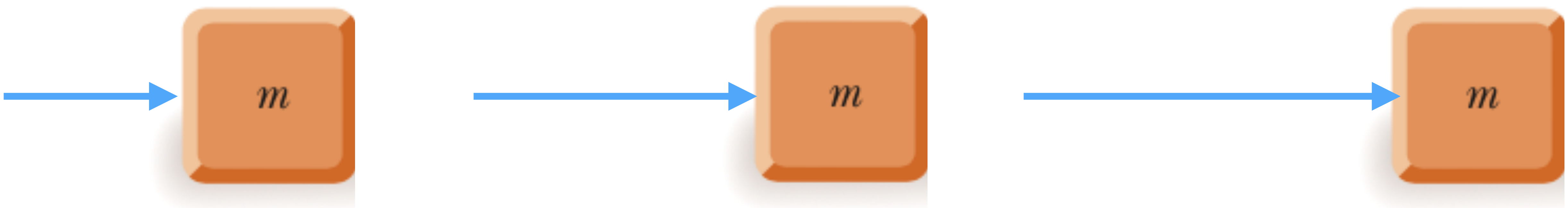
How would you calculate the work done?



$$W = \vec{F} \cdot \Delta \vec{r}$$

Work

How would you calculate the work done?

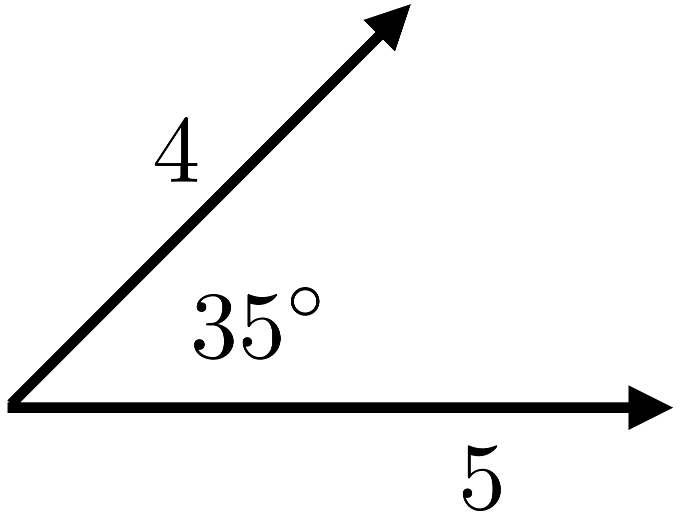


$$\cancel{W = \vec{F} \cdot \Delta\vec{r}} \qquad\qquad W = \int \vec{F} \cdot d\vec{r}$$

Question #13

Compute the dot product of the two vectors

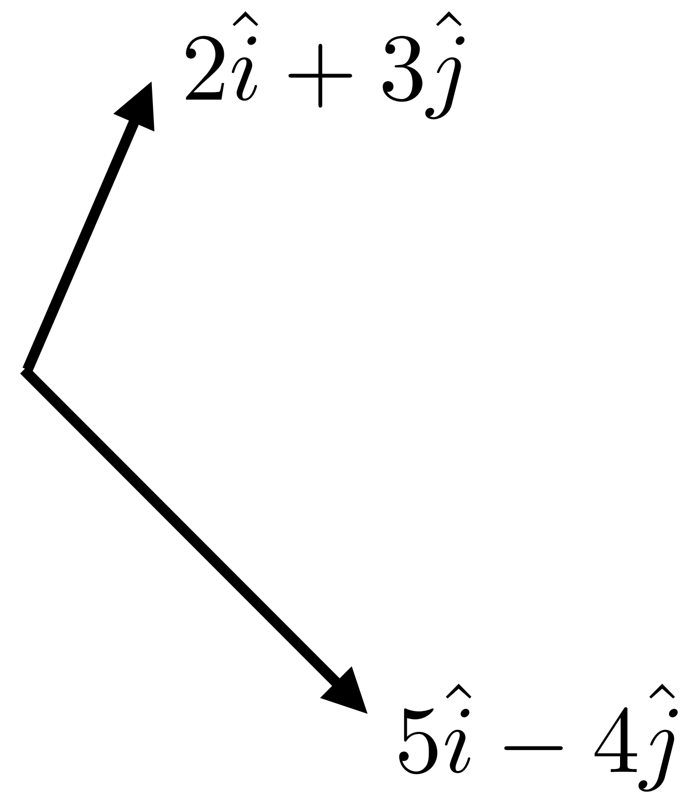
a) 12
b) 16
c) 11
d) -18



Question #14

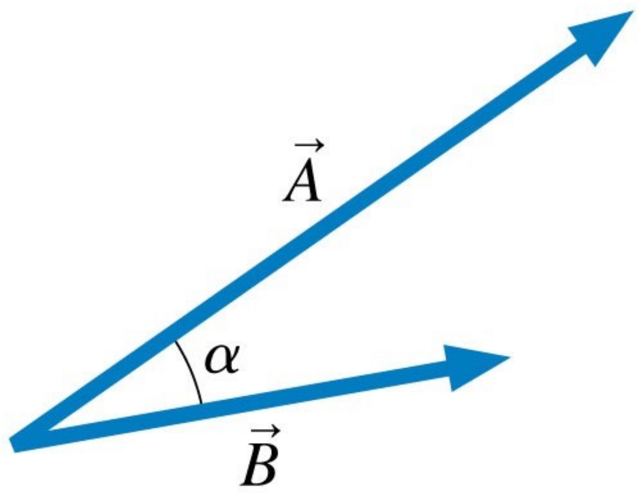
Compute the dot product of the two vectors

a) 12
b) 22
c) -22
d) -2
e) 16



The Dot Product

$$\vec{A} \cdot \vec{B} = AB\cos\alpha$$



Also called the scalar product because the result is a scalar

Dot Product using components

$$\vec{A} = A_x\hat{\imath} + A_y\hat{\jmath}$$

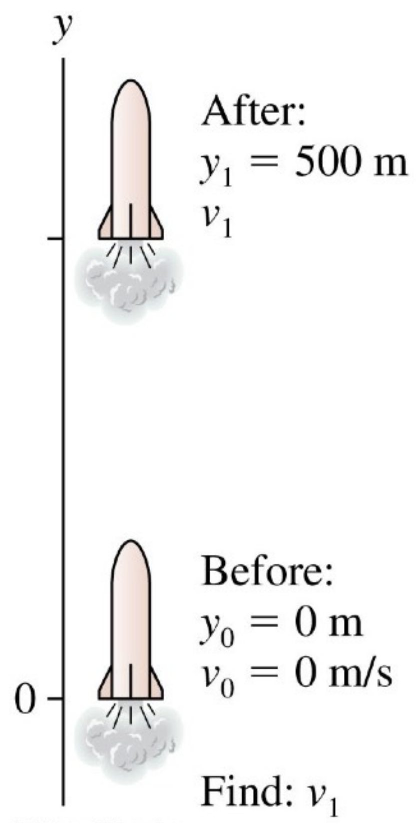
and $\vec{B} = B_x\hat{\imath} + B_y\hat{\jmath},$

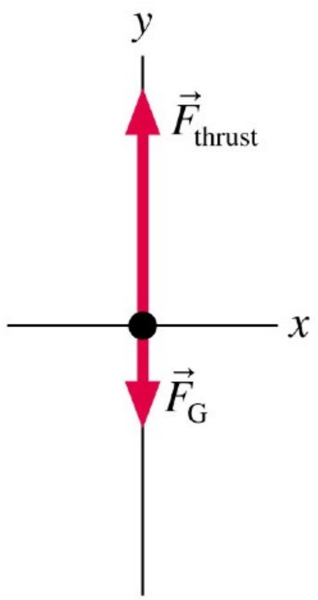
the dot product is the sum of the products of the components:

$$\vec{A} \cdot \vec{B} = A_x B_x + A_y B_y$$

Work during a rocket launch

A 150,000 kg rocket is launched straight up. The rocket motor generates a thrust of 4,000,000 N. What is the rocket's speed at a height of 500 m? Ignore air resistance and mass losses.





Using the dot product to compute work

Question #15

A 70-kg skier is gliding at 2.0 m/s when he starts down a very slippery 50-m long, 10 degree slope. What is his speed at the bottom?

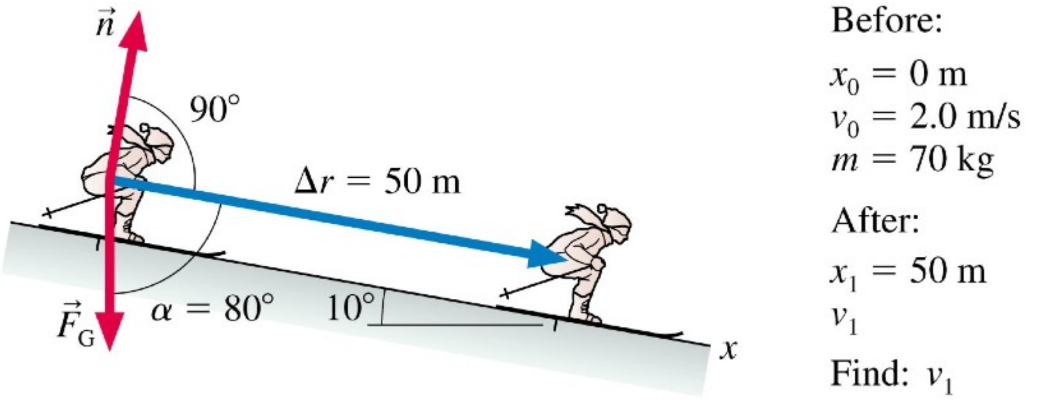
How much work does gravity do?

a) $mg\sin\theta$

b) $-mg\sin\theta$

c) $-mg\sin\theta\Delta x$

d) $mg\sin\theta\Delta x$



Question #16

Pushing horizontally, you move a box a distance "d" up an incline.

How much work is done by this push force?

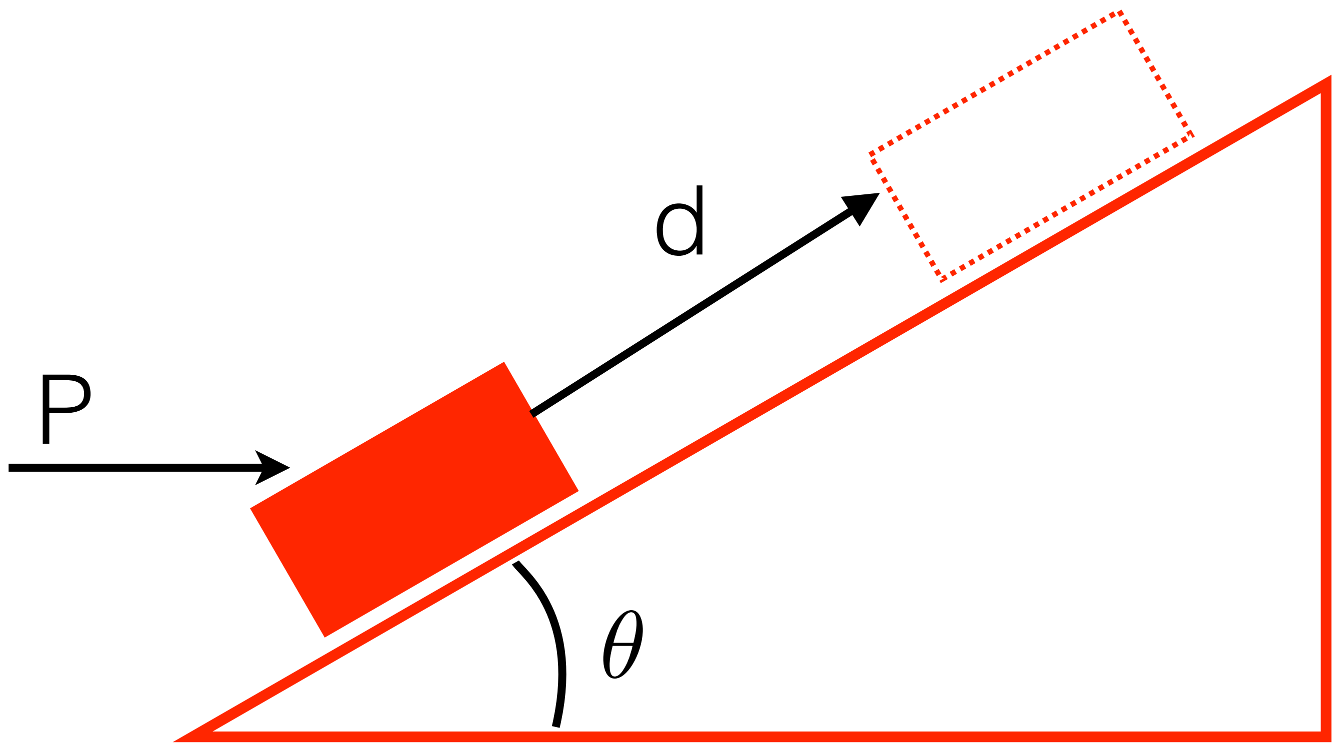
a) $-P \sin\theta d$

b) $-P \cos\theta d$

c) $P \cos\theta d$

d) $P \cos\theta$

e) $P \sin\theta d$



Question #17

Pushing horizontally, you move a box a distance "d" up an incline.

How much work is done by gravity?

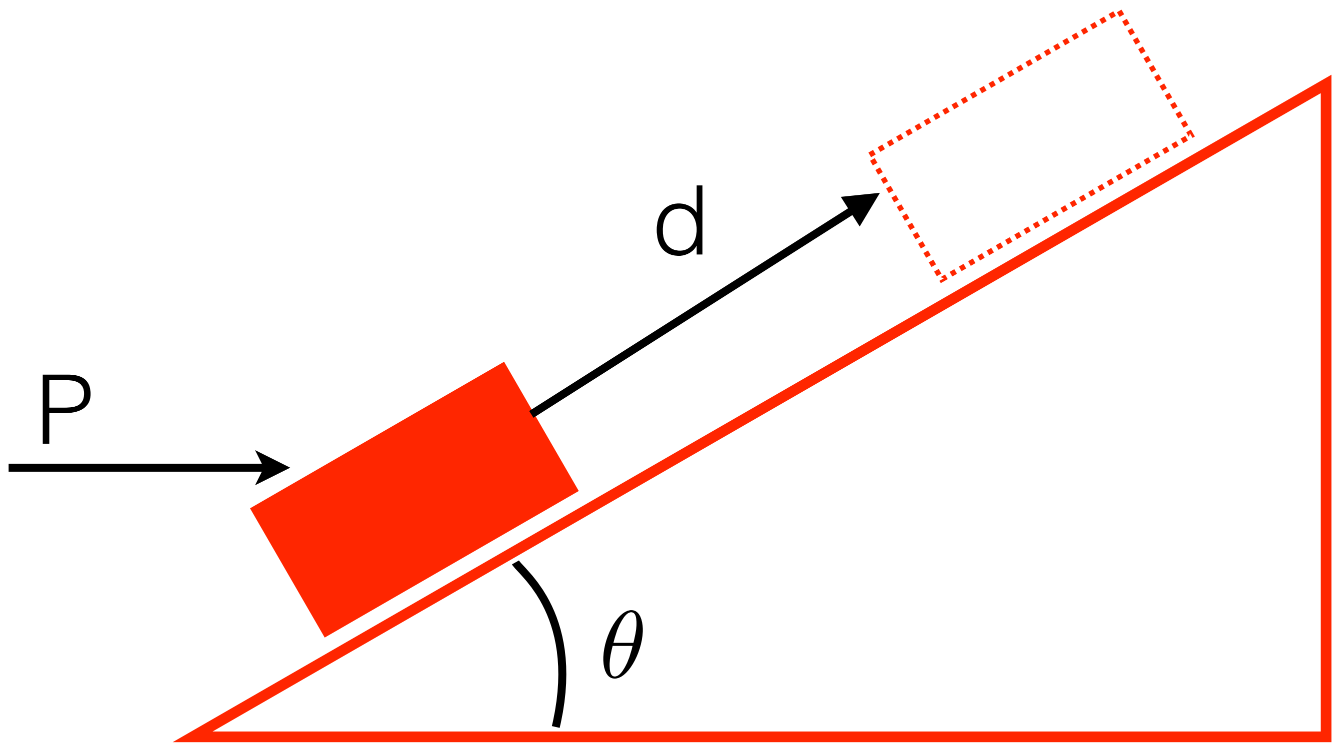
a) $-mg\sin\theta d$

b) $mg\sin\theta d$

c) $mg\cos\theta d$

d) $-mg\cos\theta d$

e) $-mg\sin\theta$



Springs and rubber bands

Question #18

Is the force of the sling shot on the rock constant?

b) yes c) no

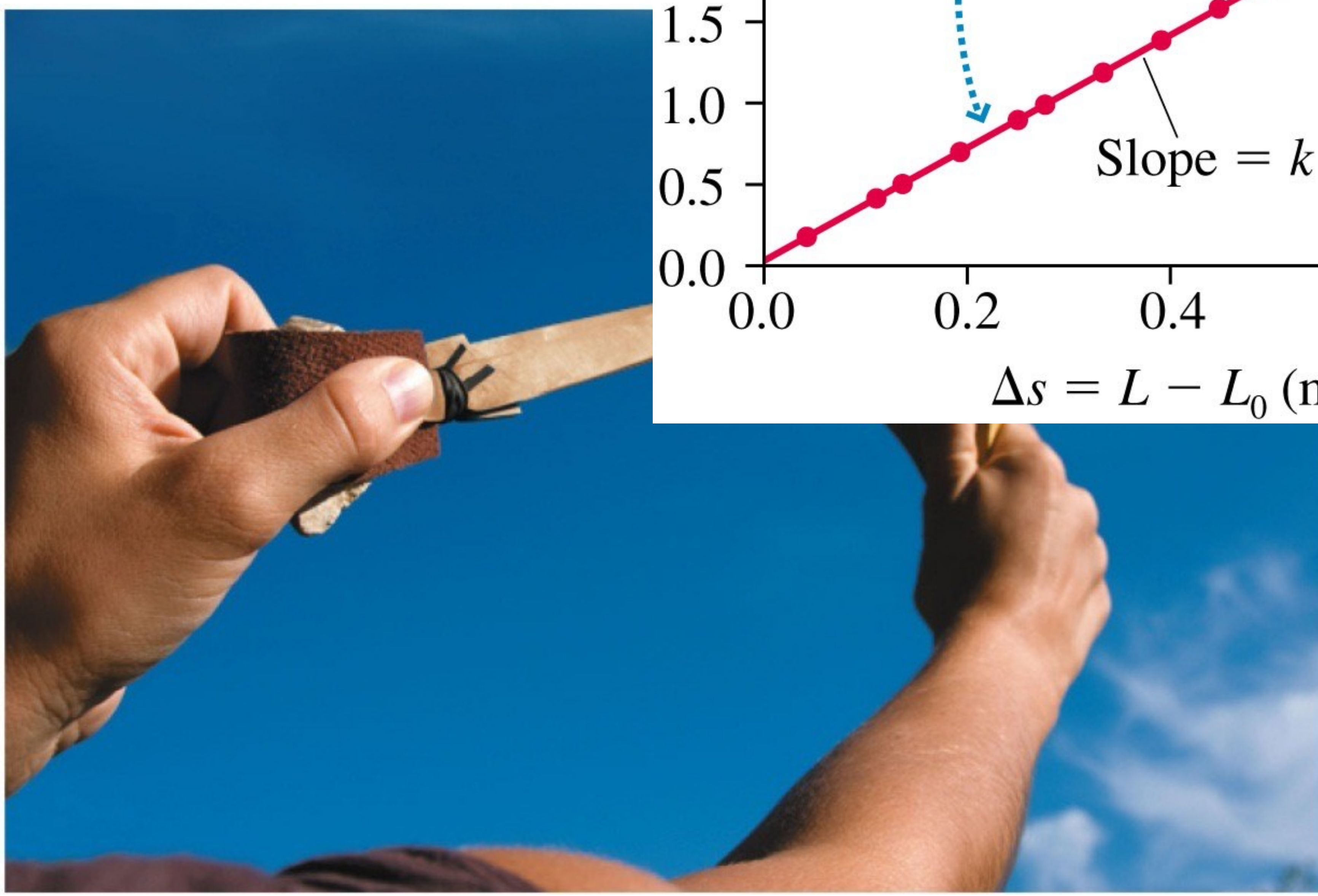
Springs and rubber bands

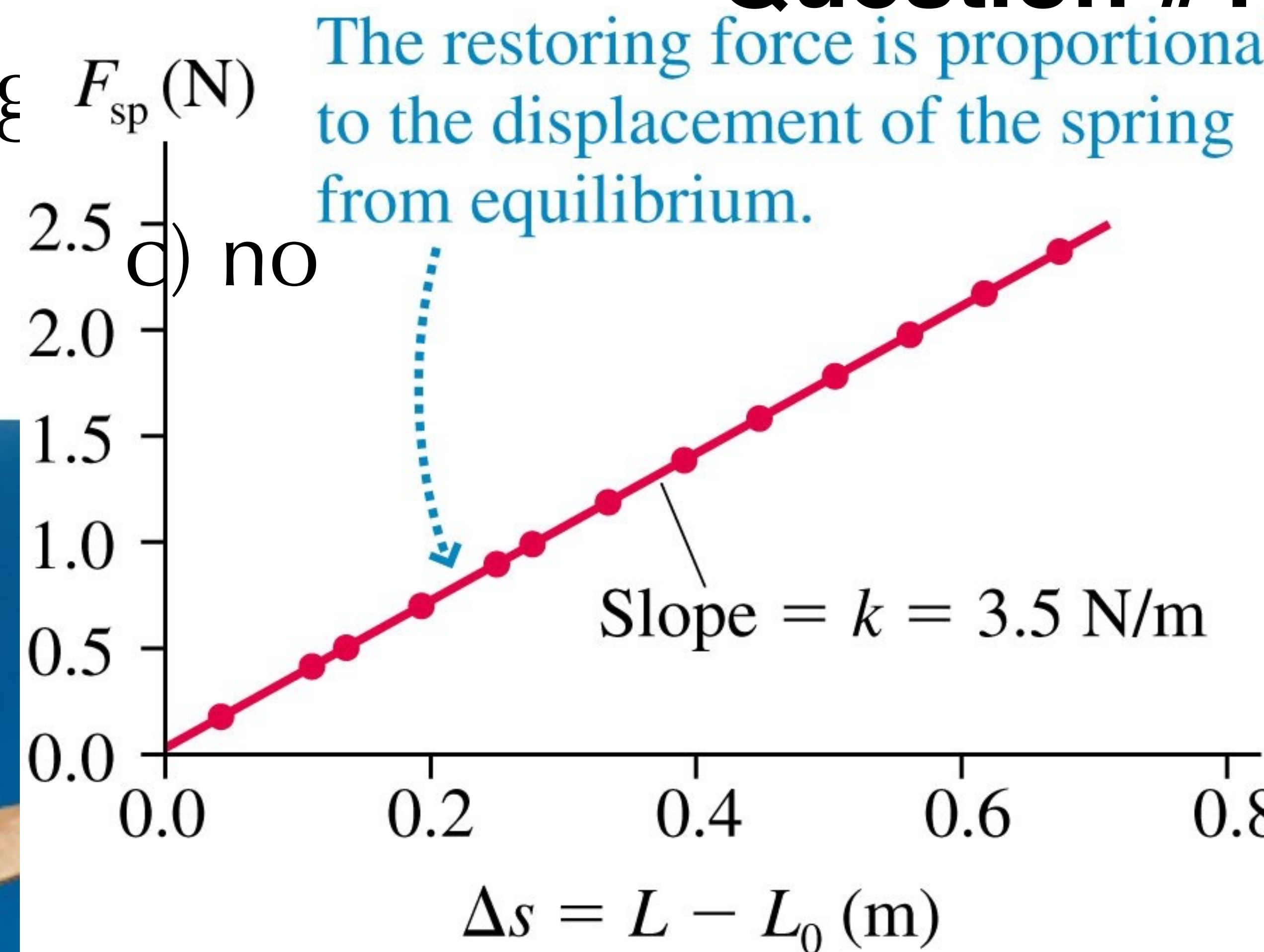
Question #18

Is the force of the sling

b) yes

c) no



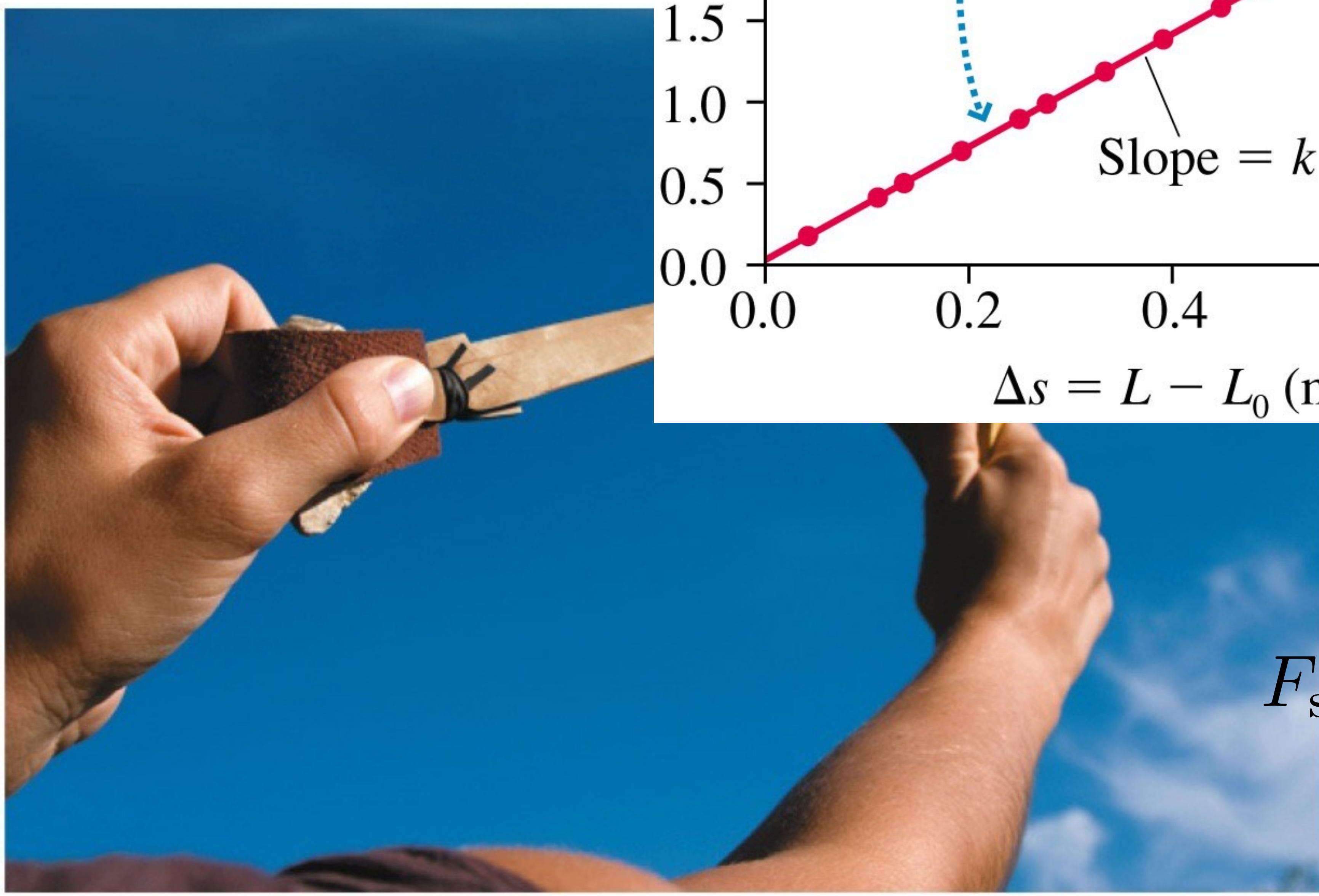


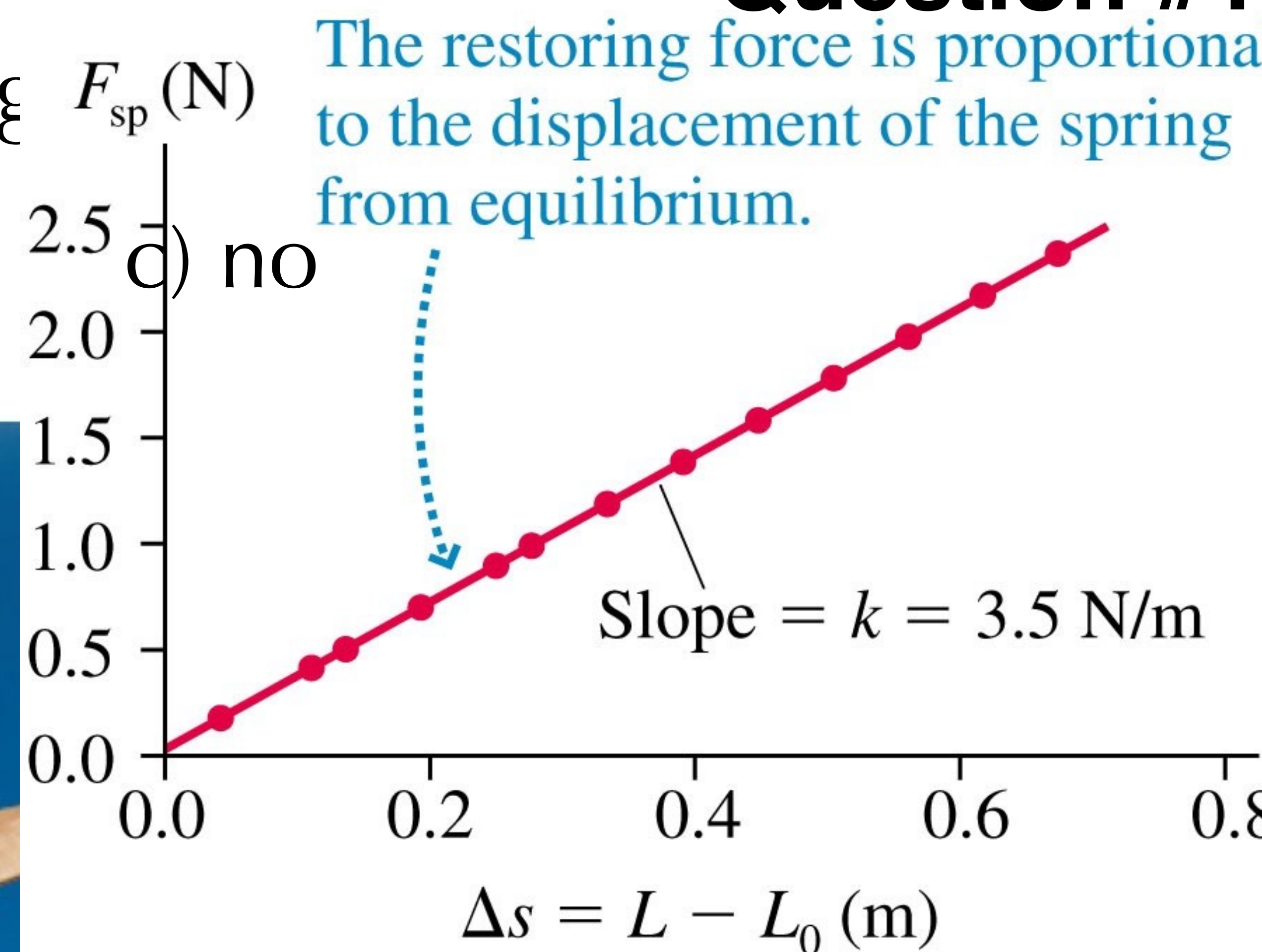
Springs and rubber bands

Question #18

Is the force of the sling

b) yes c) no

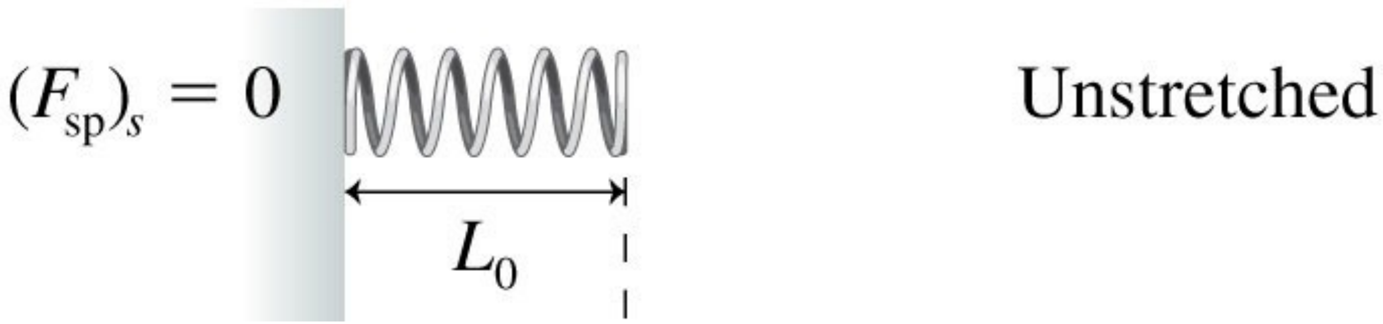




$$F_{\text{sp}} = -k\Delta s$$

Why the negative sign?

$$F_{\text{sp}} = -k\Delta s$$



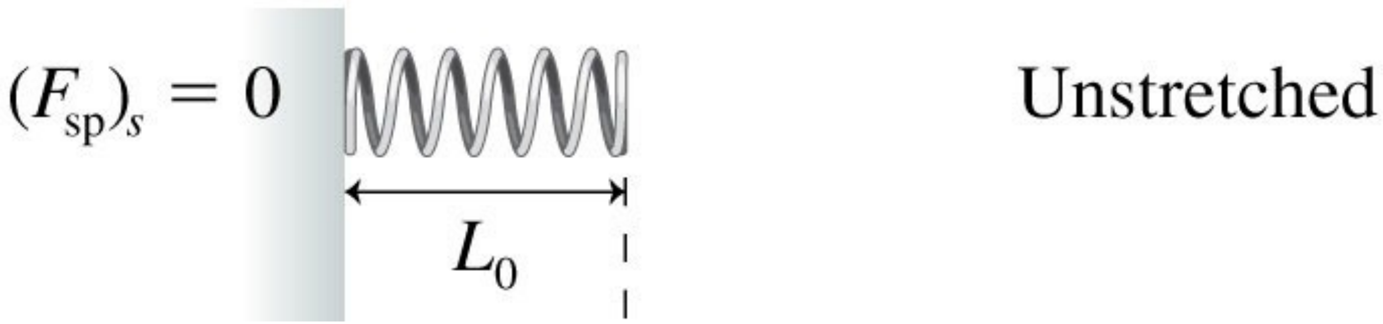
Question #19

If I compress this spring (push on it to the left), what will be the direction of the force on my hand?

a) left b) right

Why the negative sign?

$$F_{\text{sp}} = -k\Delta s$$



Question #19

If I compress this spring (push on it to the left), what will be the direction of the force on my hand?

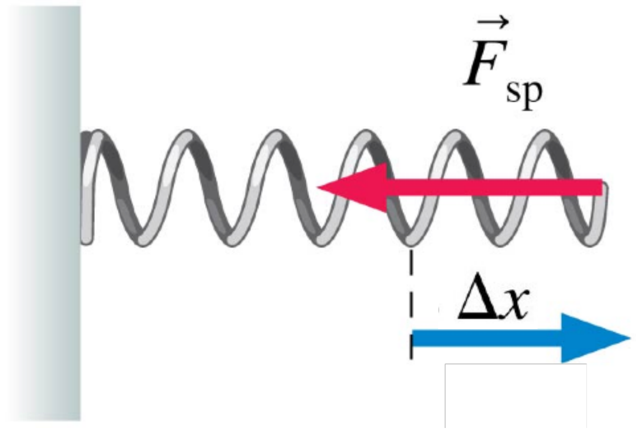
a) left b) right

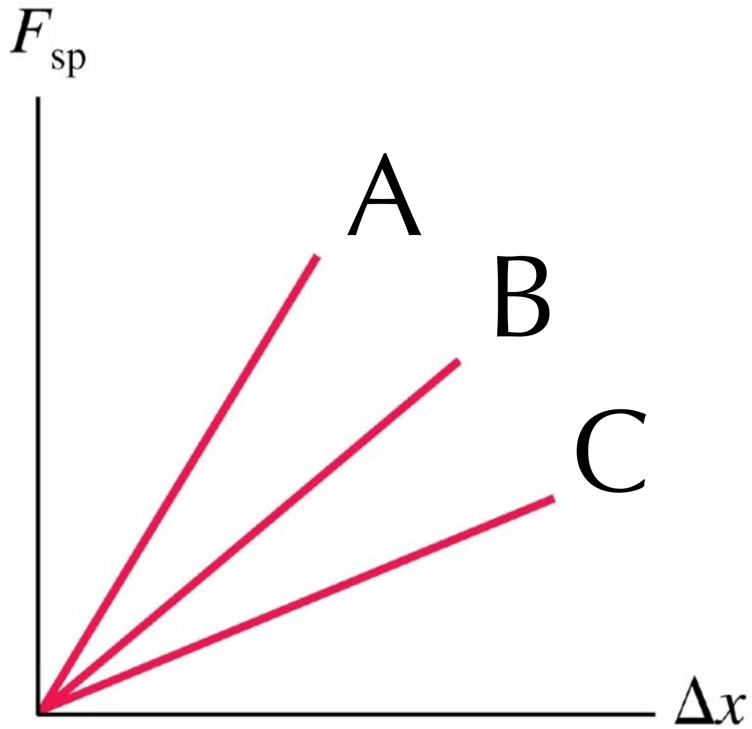
Question #20

If I stretch this spring (pull on it to the right), what will be the direction of the force on my hand?

d) right e) left

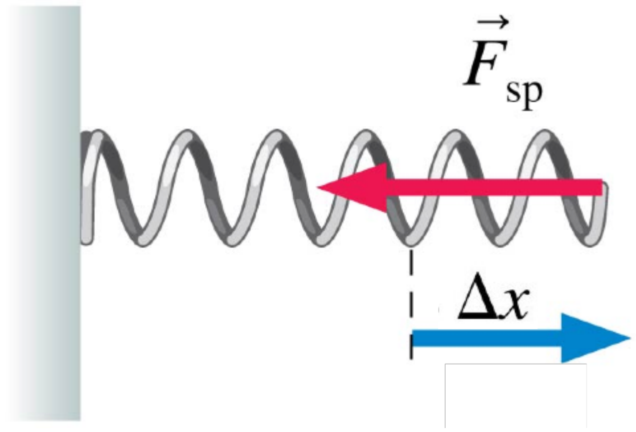
The restoring force of three springs is measured as they are stretched. Which spring has the largest spring constant?

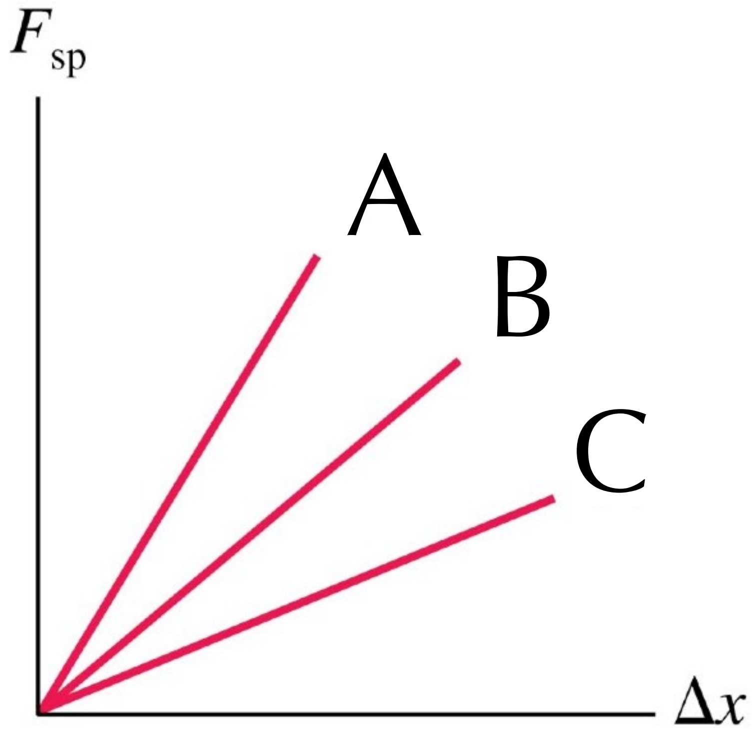




Question #21

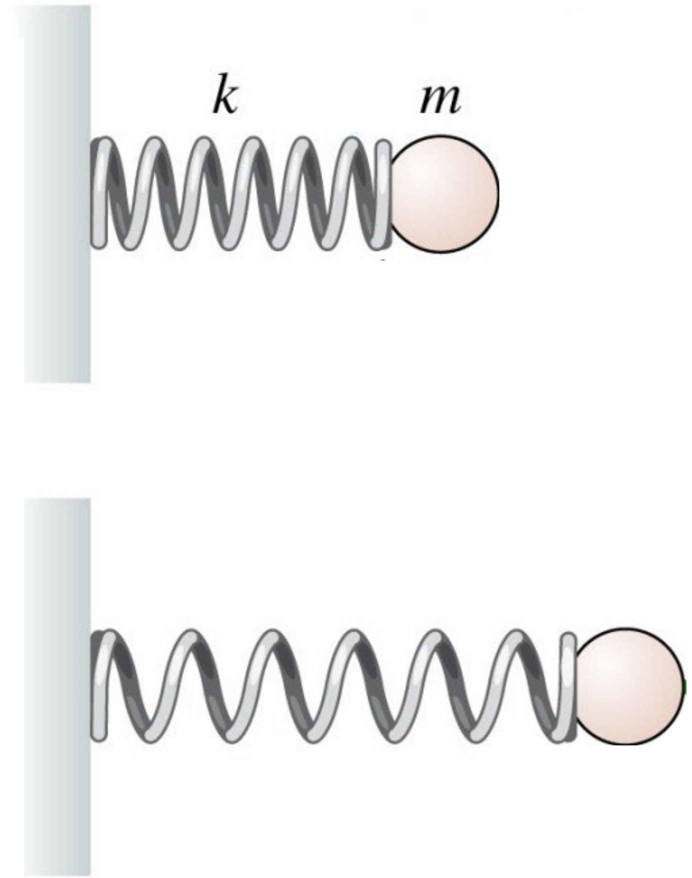
The restoring force of three springs is measured as they are stretched. Which spring has the largest spring constant?





Work done by spring

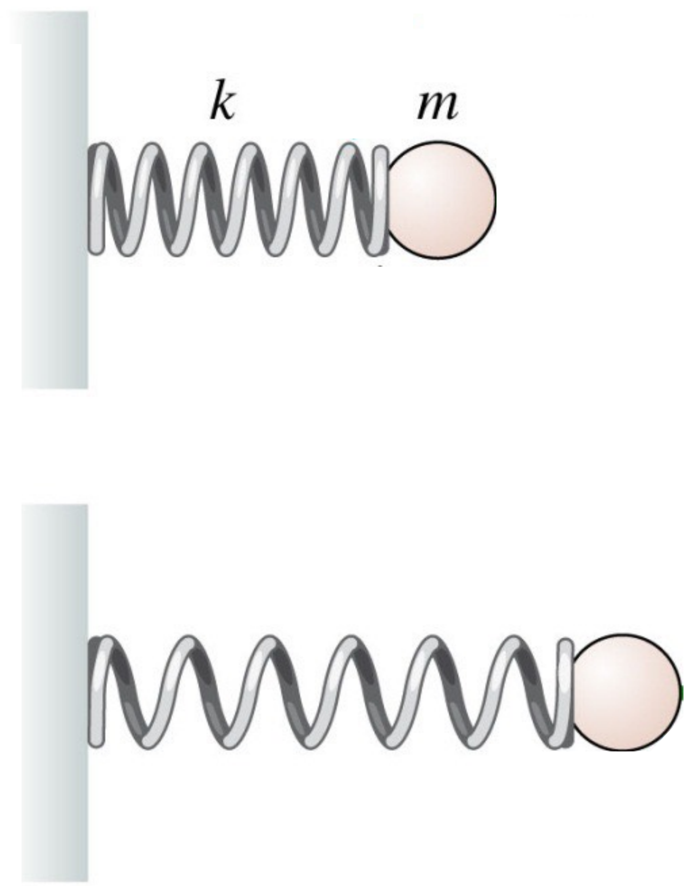
$$F_{\mathrm{sp}} = -k\Delta s$$



Work done by spring

$$F_{\text{sp}} = -k\Delta s$$

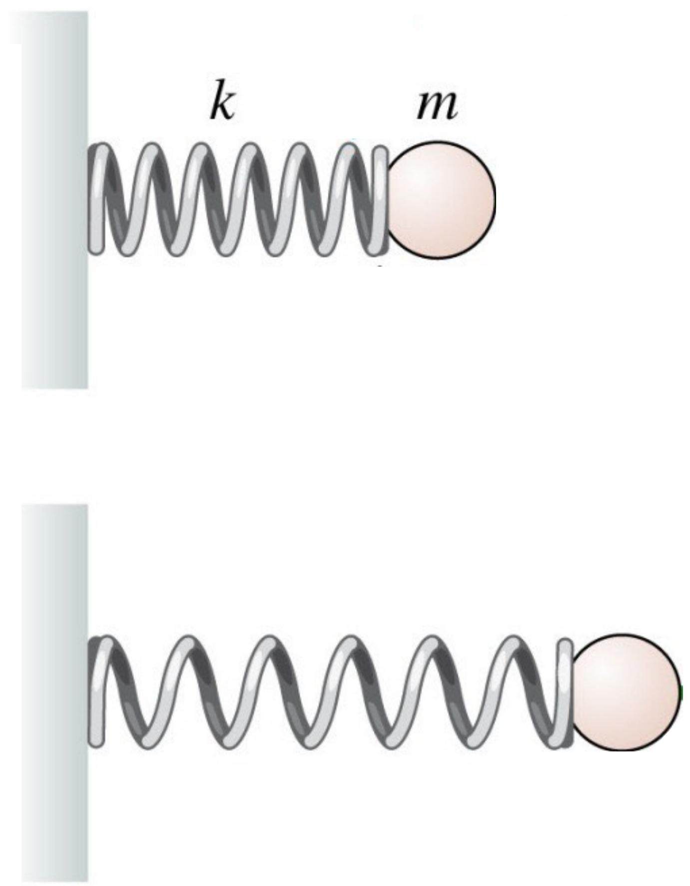
Can you calculate the work done by this spring as it pushed the ball outward?



Work done by spring

$$F_{\text{sp}} = -k\Delta s$$

Can you calculate the work done by this spring as it pushed the ball outward?

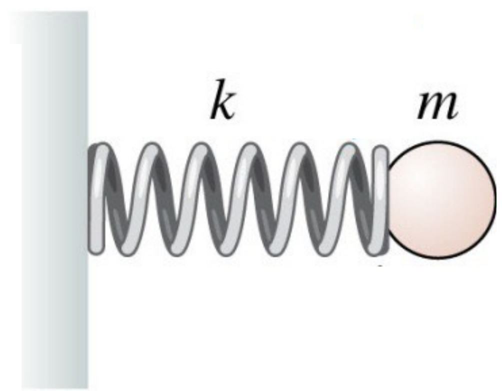


$$W = -\left(\frac{1}{2}k\Delta x_f^2 - \frac{1}{2}k\Delta x_i^2\right)$$

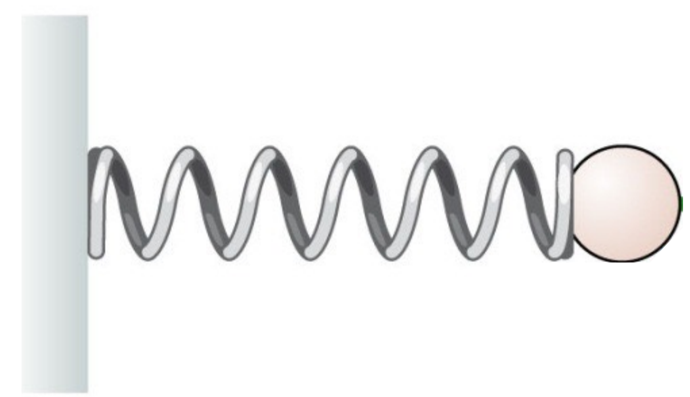
Work done by spring

$$F_{\text{sp}} = -k\Delta s$$

Can you calculate the work done by this spring as it pushed the ball outward?



$$W = -\left(\boxed{\frac{1}{2}k\Delta x_f^2} - \frac{1}{2}k\Delta x_i^2\right)$$



A box is pushed up against a spring and compresses it a distance d. When the box is released the box shoots up the hill (frictionless). What is the speed of the box at the moment it loses contact with the spring?

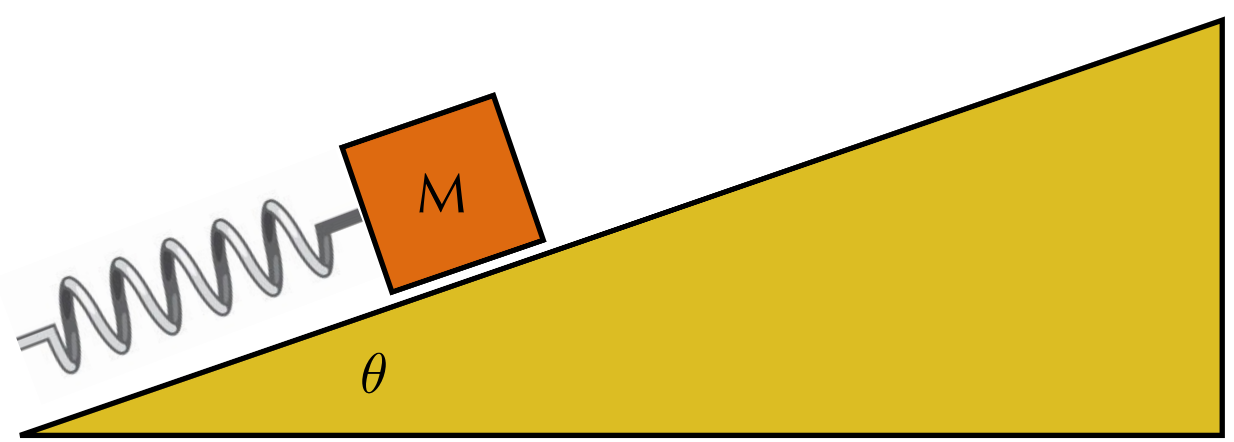
Which is a correct statement of the work-kinetic energy theorem for this problem

a) $\frac{1}{2}kd^2 - mg\sin\theta = \frac{1}{2}mv_f^2$

b) $-\frac{1}{2}kd^2 + mg\sin\theta d = \frac{1}{2}mv_f^2$

c) $\frac{1}{2}kd^2 - mg\sin\theta d = \frac{1}{2}mv_f^2$

d) $\frac{1}{2}kd^2 - mg\cos\theta d = \frac{1}{2}mv_f^2$



A box is pushed up against a spring and compresses it a distance d. When the box is released the box shoots up the hill (frictionless). What is the speed of the box at the moment it loses contact with the spring?

Question #22

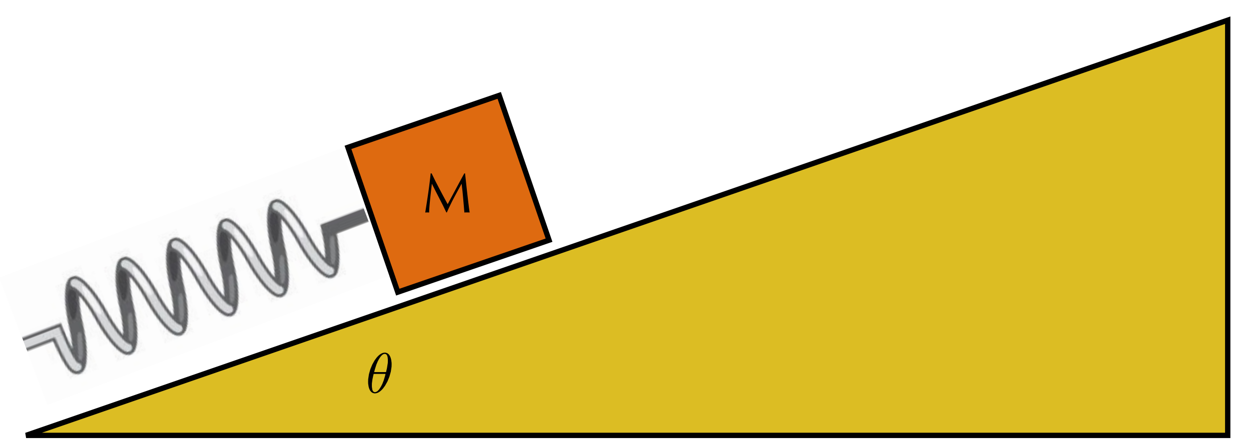
Which is a correct statement of the work-kinetic energy theorem for this problem

a) $\frac{1}{2}kd^2 - mg\sin\theta = \frac{1}{2}mv_f^2$

b) $-\frac{1}{2}kd^2 + mg\sin\theta d = \frac{1}{2}mv_f^2$

c) $\frac{1}{2}kd^2 - mg\sin\theta d = \frac{1}{2}mv_f^2$

d) $\frac{1}{2}kd^2 - mg\cos\theta d = \frac{1}{2}mv_f^2$



The Work-Kinetic Energy theorem… modified

$$\Delta K = W_{\text{net}}$$

but when friction is present….

$$\Delta K + \Delta E_{\text{th}} = W_{\text{net}}$$

$$\Delta E_{\text{th}} = f_k \Delta s$$

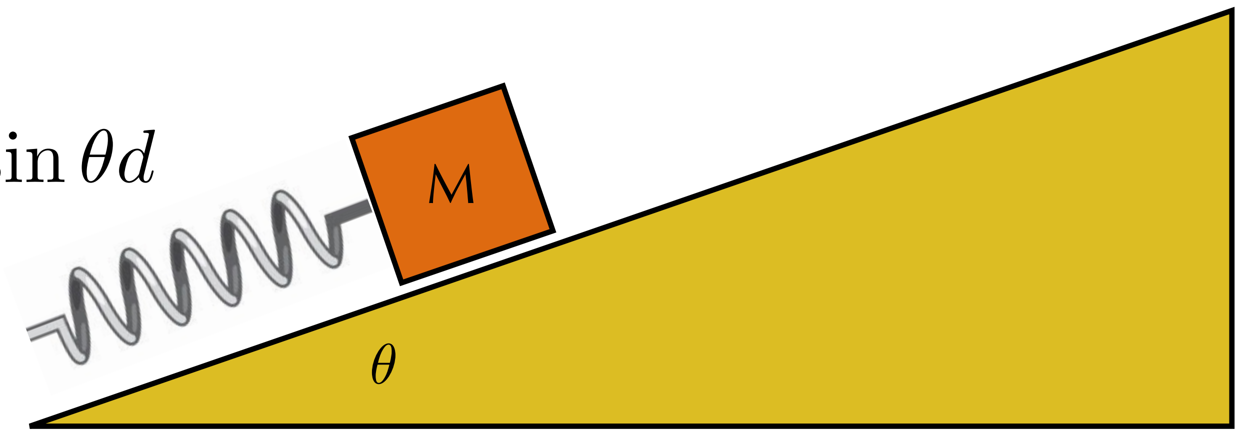
A box is pushed up against a spring and compresses it a distance d. When the box is released the box shoots up the hill (rough). What is the speed of the box at the moment it loses contact with the spring?

Which is a correct statement of the work-kinetic energy theorem for this problem?

b) $\frac{1}{2}kd^2 - mg\sin\theta d = \frac{1}{2}mv_f^2 - \mu_k mg\cos\theta d$

c) $-\frac{1}{2}kd^2 + mg\cos\theta d = \frac{1}{2}mv_f^2 + \mu_k mg\sin\theta d$

d) $\frac{1}{2}kd^2 - mg\cos\theta d = \frac{1}{2}mv_f^2 - \mu_k mg\sin\theta d$



e) $\frac{1}{2}kd^2 - mg\sin\theta d = \frac{1}{2}mv_f^2 + \mu_k mg\cos\theta d$

A box is pushed up against a spring and compresses it a distance d. When the box is released the box shoots up the hill (rough). What is the speed of the box at the moment it loses contact with the spring?

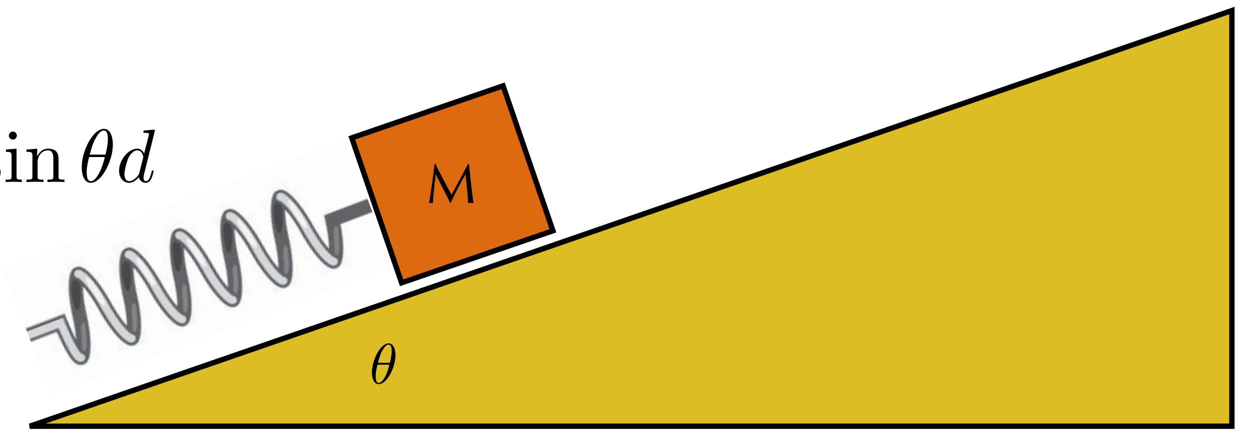
Question #23

Which is a correct statement of the work-kinetic energy theorem for this problem?

b) $\frac{1}{2}kd^2 - mg\sin\theta d = \frac{1}{2}mv_f^2 - \mu_k mg\cos\theta d$

c) $-\frac{1}{2}kd^2 + mg\cos\theta d = \frac{1}{2}mv_f^2 + \mu_k mg\sin\theta d$

d) $\frac{1}{2}kd^2 - mg\cos\theta d = \frac{1}{2}mv_f^2 - \mu_k mg\sin\theta d$



e) $\frac{1}{2}kd^2 - mg\sin\theta d = \frac{1}{2}mv_f^2 + \mu_k mg\cos\theta d$

Question #1

If it takes 2 minutes to lift this 1,000 N object (at constant speed) a distance of 100 m, what is the rate at which the crane does work on the object?

a) 830 J/s
b) 50,000 J/min
c) 50,000 Watts
d) 830 Watts
e) a), b) and d)

Question #1

If it takes 2 minutes to lift this 1,000 N object (at constant speed) a distance of 100 m, what is the rate at which the crane does work on the object?

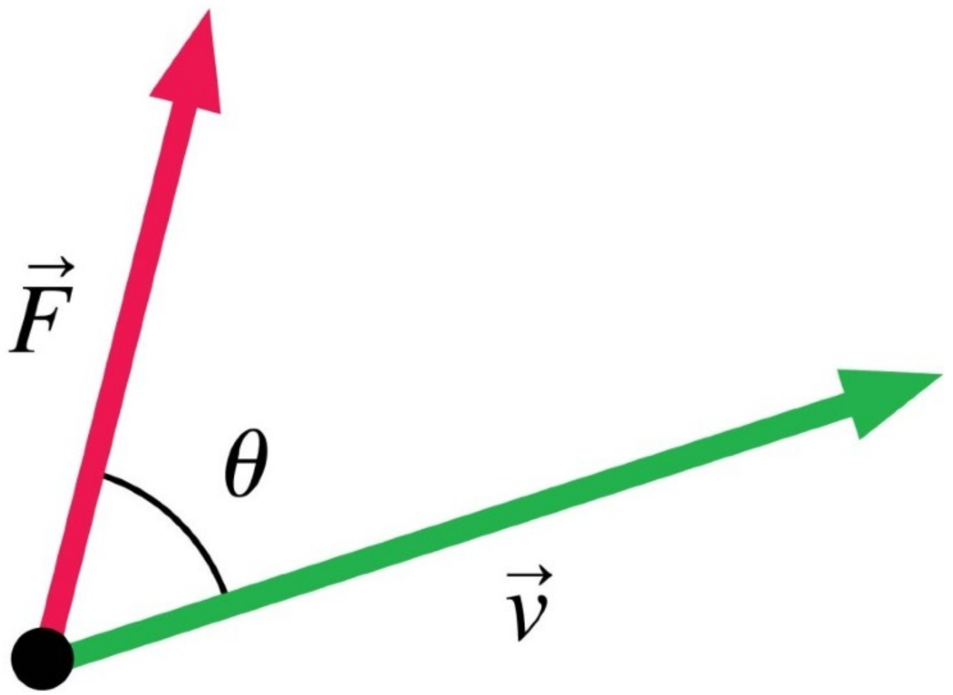
a) 830 J/s
b) 50,000 J/min
c) 50,000 Watts
d) 830 Watts
e) a), b) and d)

$$P \equiv \frac{dE_{\text{sys}}}{dt}$$

1 watt = 1 W = 1 J/s

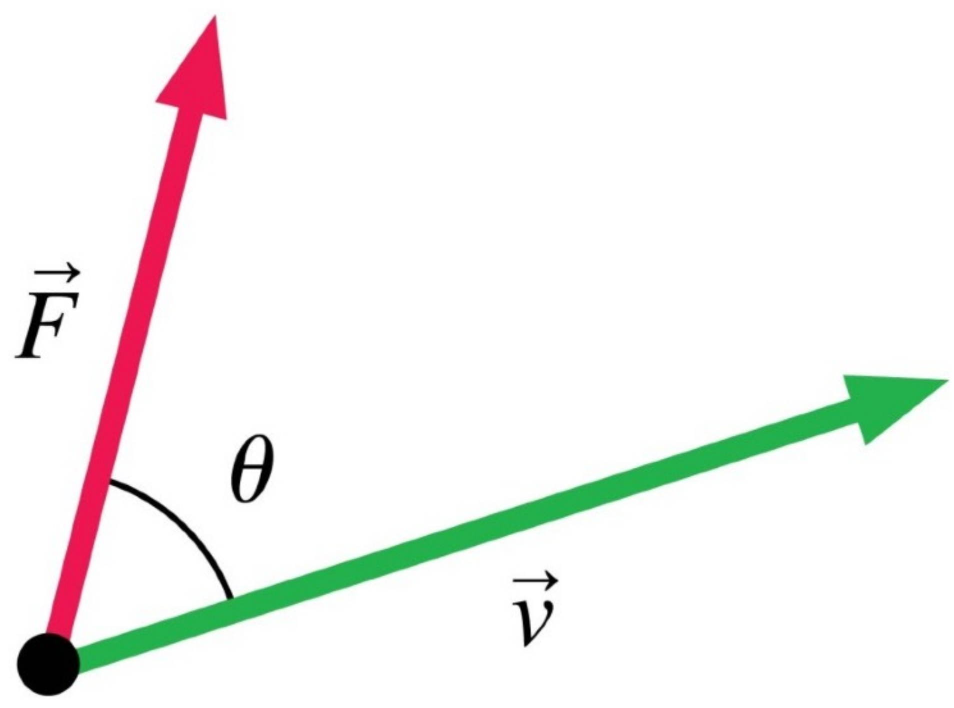
1 hp = 746 W

$$W = \vec{F} \cdot \Delta\vec{r}$$



$$W = \vec{F} \cdot \Delta\vec{r}$$

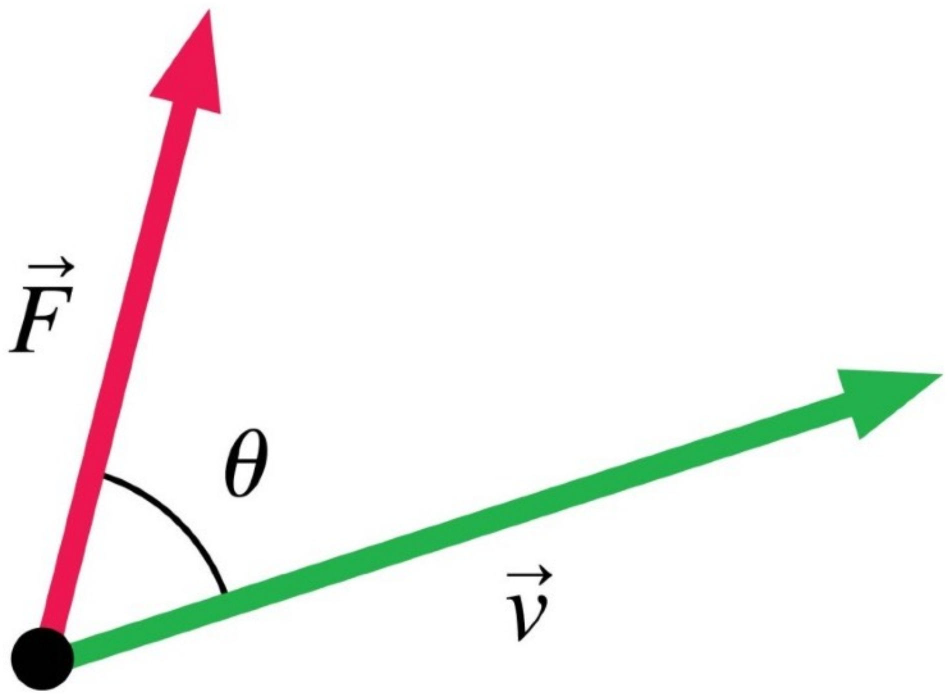
$$P = \frac{dW}{dt}$$



$$W = \vec{F} \cdot \Delta\vec{r}$$

$$P = \frac{dW}{dt}$$

$$= \vec{F} \cdot \frac{dr}{dt}$$

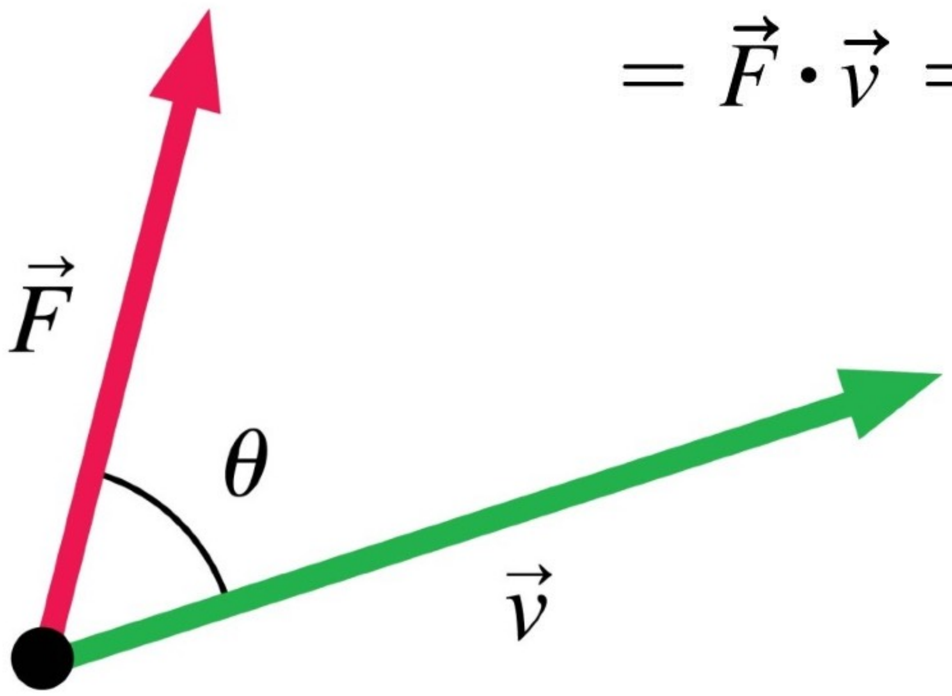


$$W = \vec{F} \cdot \Delta \vec{r}$$

$$P = \frac{dW}{dt}$$

$$= \vec{F} \cdot \frac{dr}{dt}$$

$$= \vec{F} \cdot \vec{v} = Fv\cos\theta$$

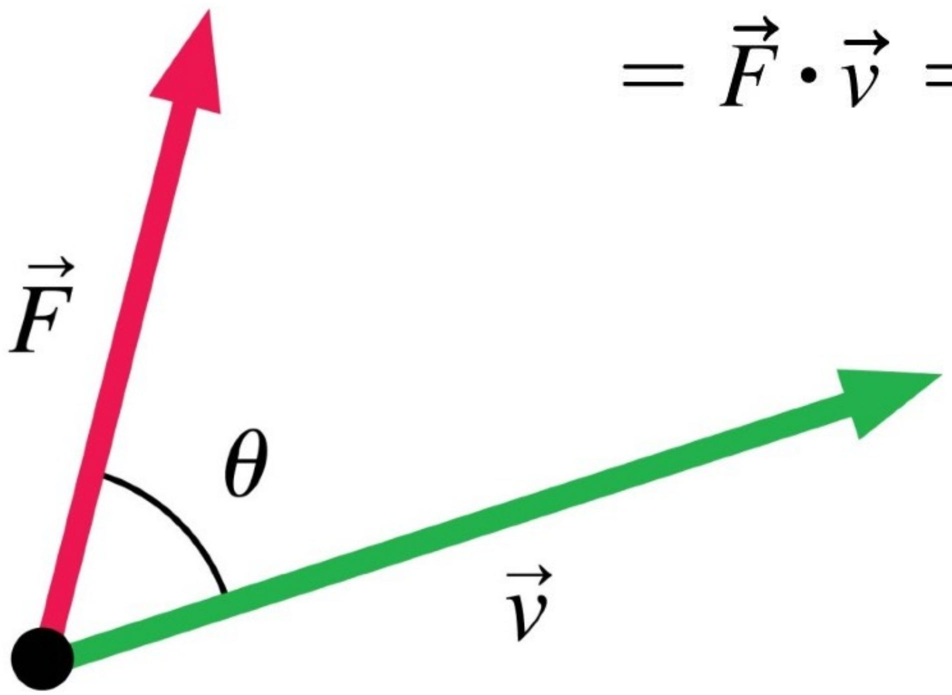


$$W = \vec{F} \cdot \Delta\vec{r}$$

$$P = \frac{dW}{dt}$$

$$= \vec{F} \cdot \frac{dr}{dt}$$

$$= \vec{F} \cdot \vec{v} = Fv\cos\theta$$



How hard is it to "peel out" at low speed?

Question #2

Four students run up the stairs in the time shown.
Which student has the largest power output?