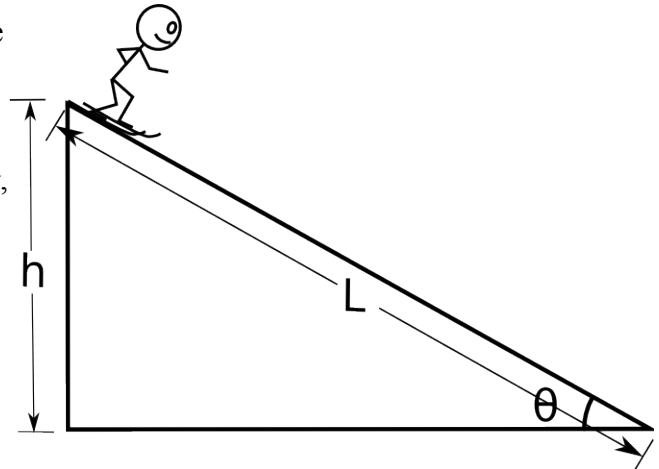


## Energy Problems – Set 2

1

Stick Skier is back for another round. Because he knows Newton was a jerk, he wants you to calculate his velocity using this fancy new **Work Energy Theorem** that he's heard so much about. He reluctantly tells you that he has a mass  $m$  (stick man is quite sensitive about his weight). The distance down the ski slope is  $L$  and it makes an angle  $\theta$  with the horizontal. The top of the hill is a vertical distance  $h$  above the bottom of the hill.

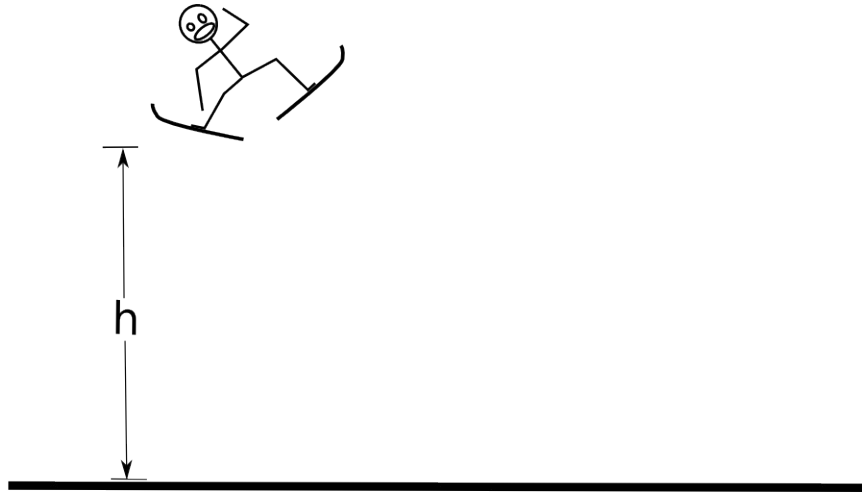
- Calculate the work done on the skier by each of the forces. (draw a free body diagram!)
- Find an expression for the **total** work,  $W_{net}$ , done on the skier. Express your answer in terms of  $m$ ,  $g$ , and  $h$  only.
- Use the **Work Energy Theorem** to find the skier's speed,  $V_f$ , at the bottom of the hill.



## Energy Problems – Set 2

2

Stick skier won't stop talking about this awesome new video game that he got last week. His buddy gets so annoyed that he throws him off the mountain.



- Calculate the net work done on stick skier and compare it to the net work from the previous question.
- Use the **Work Energy Theorem** to find an expression for the final speed of the skier.

In order to do work on an object

- a) it is necessary that friction be present.
  - b) it is necessary that friction not be present.
  - c) the object must move.
  - d) the applied force must be greater than the reaction force of the object.
- 

A person drops one rock from rest and it falls 100 meters down a cliff before hitting the ground. The person then throws an identical rock downward.

The amount of kinetic energy gained by the rock dropped from rest is \_\_\_\_\_ that gained by the second rock (only consider the gain *after* the throw).

- a) greater than
- b) equal to
- c) less than

The change in speed (the difference it's initial speed and it's speed just before hitting the ground) of the rock dropped from rest is \_\_\_\_\_ that of the second rock.

- a) greater than
  - b) equal to
  - c) less than
- 

Three cars (car F, car G and car H) are moving with the same velocity, and slam on the brakes. The most massive car is F and the least massive is H.

Assuming all three have identical tires, for which car does friction do the most work?

- a) Car F
- b) Car G
- c) Car H
- d) Each car does the same friction work.

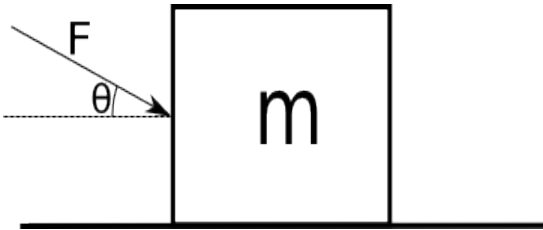
Assuming all three have identical tires, which car travels the longest distance to skid to a stop?

- a) Car F
  - b) Car G
  - c) Car H
  - d) They all travel the same distance.
-

## Energy Problems – Set 2

A box with mass  $m$ , initially at rest, is pushed a distance  $d$  along a surface with a force  $F$  making an angle  $\theta$  with the horizontal. The coefficient of friction between the box and the surface is  $\mu_k$ .

- Find an expression for the final velocity of the box,  $V_f$ , using Work-Energy techniques.
- Find an expression for final velocity of the box using Newton's Second Law and kinematics and show that the answer is the same.



## Energy Problems – Set 2

Evil Alien Pirates (EAPs) are dropping cannon balls on us from outer space. If they are dropping the balls from exactly 1 Earth radius above the Earth, calculate the velocity of the cannon balls as they strike the surface.

Because the balls are being dropped from SO high, we can't assume that gravity is constant. We must instead use Newton's Universal Law of Gravitation (Pirates know it!):

$$F_G = -\frac{GM_1M_2}{r^2} \hat{r}$$

The  $r$  in the equation above is the distance between the centers of the two massive objects.

Use the Work Energy Theorem to Find an analytic expression for the final velocity.

$$G = 6.67 \times 10^{-11} \frac{m^3}{kg \cdot s^2}$$

$$R_{Earth} = 6.36 \times 10^3 \text{ km}$$

$$M_{Earth} = 5.97 \times 10^{24} \text{ kg}$$



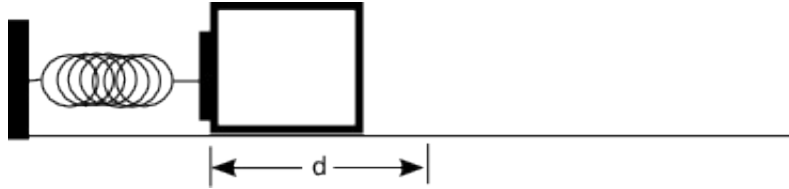
## Energy Problems – Set 2

6

Springs exert a force that opposes being stretched or compressed. Hook's law states that the magnitude of the force exerted by the spring is not constant, but is proportional to the amount of compression/extension and in the opposite direction. Mathematically, it is written:

$$\vec{F}_s = -k \vec{x}$$

The spring constant,  $k$ , represents the strength of the spring and  $x$  is the displacement of the spring from its equilibrium position (the position where it's not exerting any force). The negative sign indicates that the force opposes the displacement  $x$ .



- a) A block of mass  $m$  is pushed against a spring of spring constant  $k$  and the spring is compressed a distance  $d$ . Calculate the work done by the spring after it is released.

*HINT: solve the following integral*

$$W_s = \int_0^d \vec{F}_s \cdot d\vec{x}$$

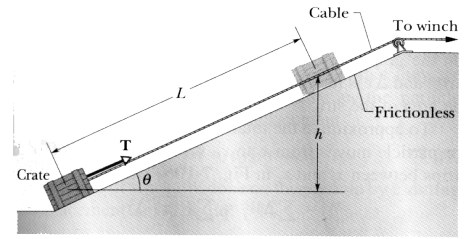
- b) What is the block's velocity after leaving the spring?

## Energy Problems – Set 2

7

An initially stationary crate of mass  $m$  is pulled a distance  $L$  up a frictionless ramp to a height  $h$  where it stops.

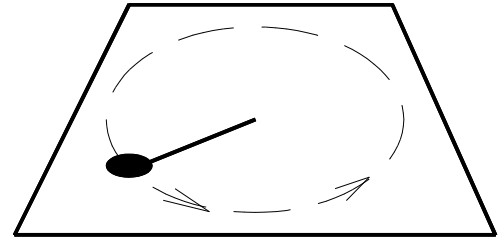
- Find an expression for the work  $W_g$  done on the crate by gravity during the lift in terms of  $m$ ,  $h$ , and  $g$ .
- Find an expression for the work  $W_T$  done on the crate by the tension  $T$  in the cable during the lift in terms of  $m$ ,  $h$  and  $g$ .



## Energy Problems – Set 2

8

A particle of mass  $m$  moves in a horizontal circle of radius  $R$  on a rough table. It is attached to a string fixed at the center of the circle. The coefficient of friction between the mass and the table is  $\mu_k$ .



- Calculate the net work done on the puck after one revolution.
- The initial velocity of the puck is  $v_0$ . After completing one revolution, the velocity of the puck is  $\frac{1}{2}v_0$ . Find an expression for  $\mu_k$  in terms of  $v_0$ ,  $\pi$ ,  $R$  and  $g$ .
- How many times will the particle go around? (You should get a number)