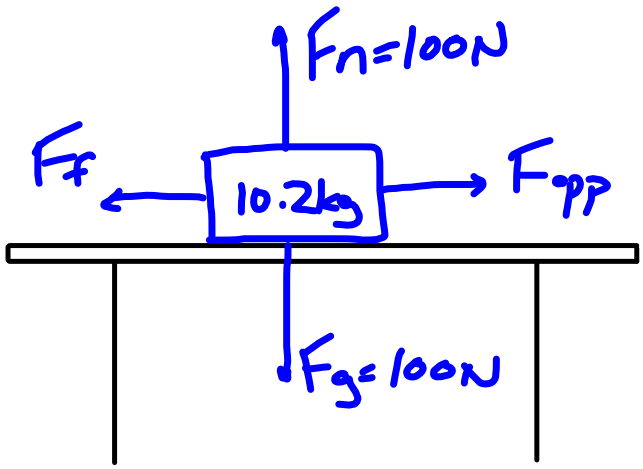
Some Summary Notes on Friction (Static and Kinetic)

for more details see chapters 3.3 and 3.4 in your text book

Friction

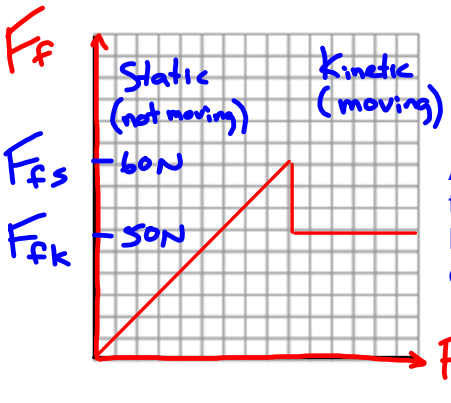


$F_g = mg$
$= 10.2 \times 9.8$
$= 100N$

The force of friction depends on two things:

1. normal force
2. type of materials interacting

Frictional Force (F_f) versus Applied (F_a)



As the object begins to move, the F_f remains constant even as F_a continues to increase.

F_{fs} → force that must be overcome to start an object moving.

F_{fk} → ongoing frictional force that opposes motion

As the applied force (F_a) increases, the force of friction(F_f) increases at the same rate until it can no longer hold back the object from moving.

coefficient of static friction

→ defined at point of maximum static frictional force

$$\mu_s = \frac{F_{fs}}{F_n}$$

coefficient of kinetic friction

→ defined using ongoing kinetic frictional force.

$$\mu_k = \frac{F_{fk}}{F_n}$$

in our example:

$F_n = 100N$

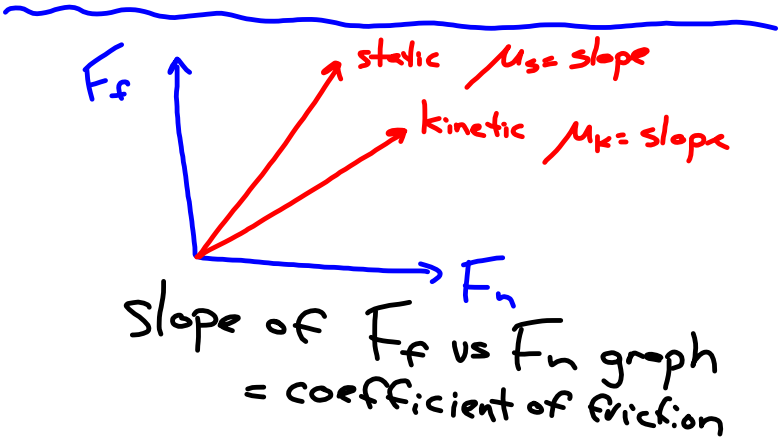
$F_{fs} = 60N$

$$\mu_s = \frac{F_{fs}}{F_n} = \frac{60N}{100N} = 0.60$$

$F_n = 100N$

$F_{fk} = 50N$

$$\mu_k = \frac{F_{fk}}{F_n} = \frac{50N}{100N} = 0.50$$



Slope of F_f vs F_n graph = coefficient of friction

If we know the coefficient of friction we can calculate the frictional force....

$$\mu_s = \frac{F_{fs}}{F_n}$$

$$\mu_k = \frac{F_{fk}}{F_n}$$

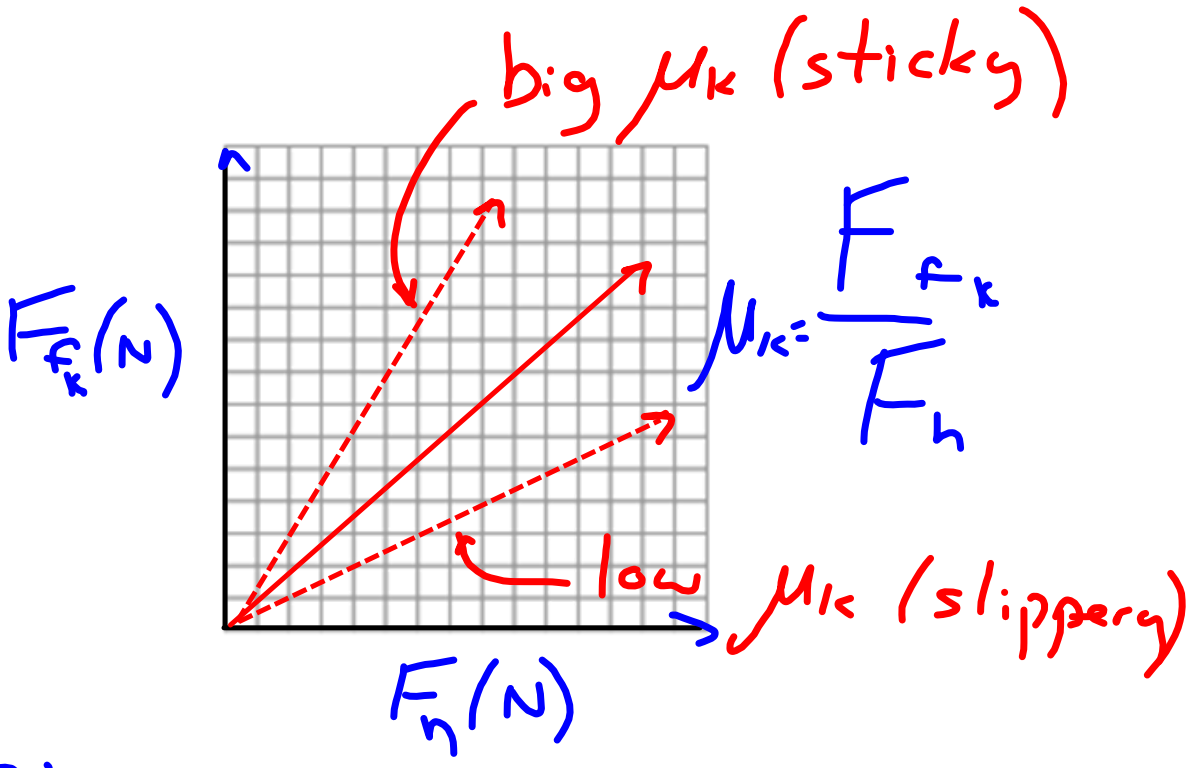
$$F_{fs} = \mu_s F_n$$

force required to start an object moving.

$$F_{fk} = \mu_k F_n$$

force opposing motion for a moving object.

Coefficient of Kinetic Friction - a closer look



Slope of a F_{f_k} vs F_n graph is the coefficient of kinetic friction.

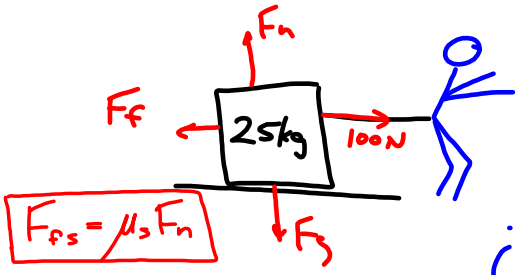
Sample Problems

Friction : Practice Problems

Some sprinters use a weight to help in training for sprint races. A strap is attached to a block and then dragged behind the sprinter. In this example a 25 kg block is used. The coefficient of static friction (μ_s) is 0.40 and the coefficient of kinetic friction is (μ_k)is 0.30 between the block and the track.

A. The sprinter can apply of constant force of 100N on the block.

a. Is the applied force high enough to start the block moving?



$F_g = 245$

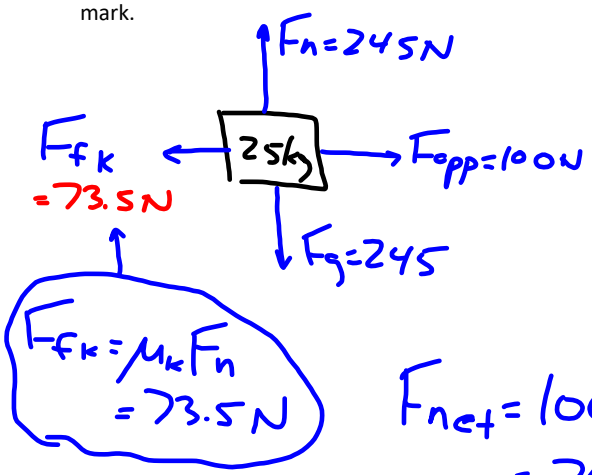
$F_n = 245$

$F_{fs} = 98N$

$\therefore$ it will move

$(F_{opp} > F_{fs})$

b. If the block does start moving, how long (in seconds) does it take to travel 20m and at what velocity will the block be moving at the 20m mark.



$F_{net} = 100 - 73.5$

$= 26.5N$

$a = F_{net}/m$

$= 26.5N / 25kg$

$= 1.06 m/s^2$

$a = 1.06 m/s^2$

$V_1 = 0 m/s$

$\Delta d = 20m$

$\Delta t = ?$

} use eqn ③

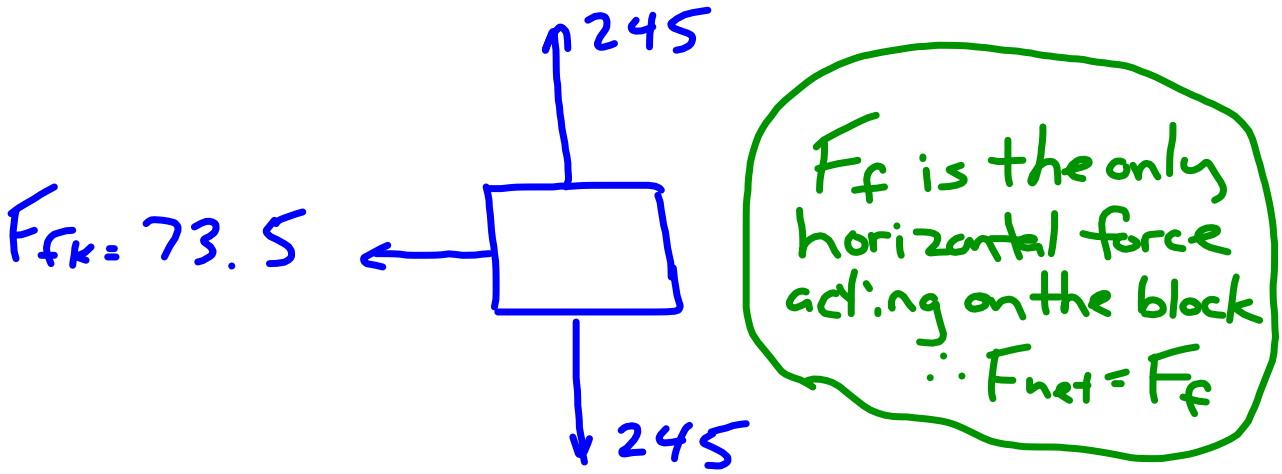
$\Delta d = V_1 \Delta t + \frac{1}{2} a \Delta t^2$

$\Delta t = 6.14s$

to find V_2 use eqn ⑤

$V_2 = 6.5 m/s$

B. At the end of the 20m the sprinter releases the strap and allows the block to coast to a stop. How long (in seconds) and how far does the block travel before stopping?

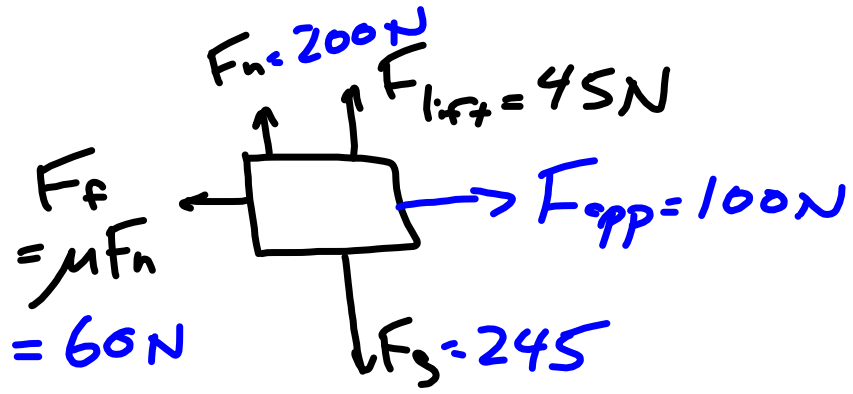


$a = F_{net}/m = 73.5/25 = 2.94\ m/s^2$

$v_1 = 6.5\ m/s$
$a = -2.94\ m/s^2$
$v_2 = 0$

$\Delta d = 7.2\ m$ (5)
$\Delta t = 2.2\ s$ (2)

C. In this example a balloon is attached to the block to "lighten" the load. The lift provided by the balloon is 45N.
How long (in secs) does it take in this new scenario to travel 20m and at what velocity will the block be moving at the 20m mark?



$F_{net} = 100 - 60 = 40N$

$a = F_{net}/m = 1.6 m/s^2$

$a = 1.6 m/s^2, V_1 = 0, \Delta d = 20m$

$\Delta t = 5 s$ (from eqn ③)

$V_2 = 8 m/s$ (from eqn ⑤)

Practice Problems

These problems are provided only for those students who want some extra practice, they do not need to be completed.

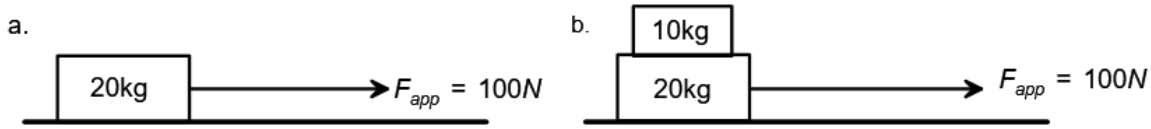
Friction – Static and Kinetic

Friction Practice Questions (only for students who want extra practice):

1. A horizontal force of 50.0N is required to pull a 8.0kg block of aluminum at a uniform velocity across a horizontal wooden desk. What is the coefficient of kinetic friction between the block and the desk?
2. A 125kg block of steel is being pushed across a wooden floor. If the coefficient of static friction (μ_s)is 0.45 and the coefficient of kinetic friction (μ_k)is 0.25 calculate the minimum force required to get the steel block moving and the force required to keep it moving once it is moving at a constant speed.
3. The driver of a 2.00×10^3 kg car applies the brakes on a dry concrete roadway. Calculate the force of friction between the tires and the road surface if μ_k=1.02.
4. A 20 kg box is dragged across a level floor with a force of 100N. The coefficient of kinetic friction between the box and the floor is 0.32 and the coefficient of static friction is 0.45.

a. Will the box start moving and if so what is the acceleration?

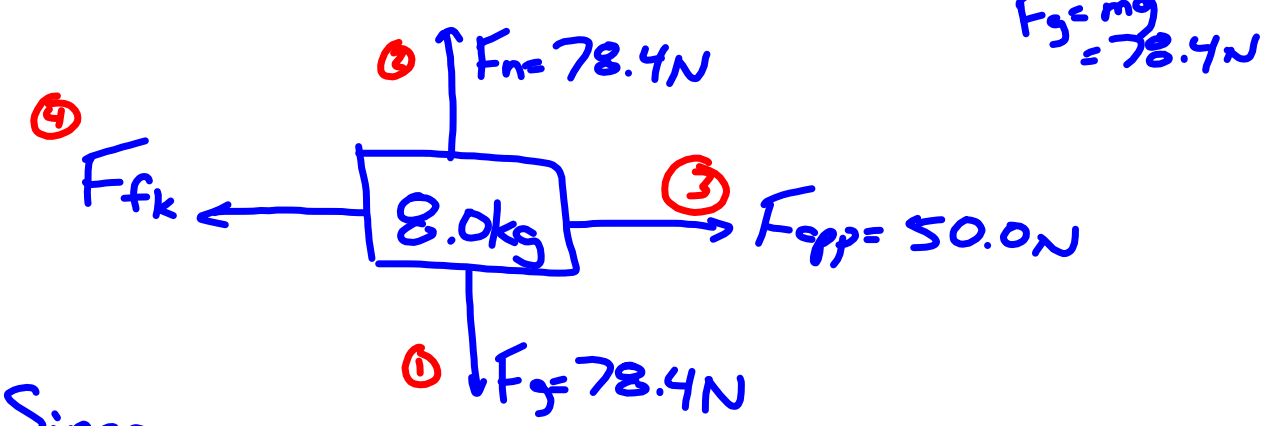
b. If a 10 kg weight is added to the box, will the 100N be enough to start the box moving and if so what is the acceleration?



5. A 0.170 kg hockey puck is travelling at 19m/s when it strikes a rough patch of ice with a coefficient of kinetic friction (μ_k)equal to 0.47. How far will the puck travel before it stops on this rough ice?

Practice Problems

1. A horizontal force of 50.0N is required to pull a 8.0kg block of aluminum at a uniform velocity across a horizontal wooden desk. What is the coefficient of kinetic friction between the block and the desk?



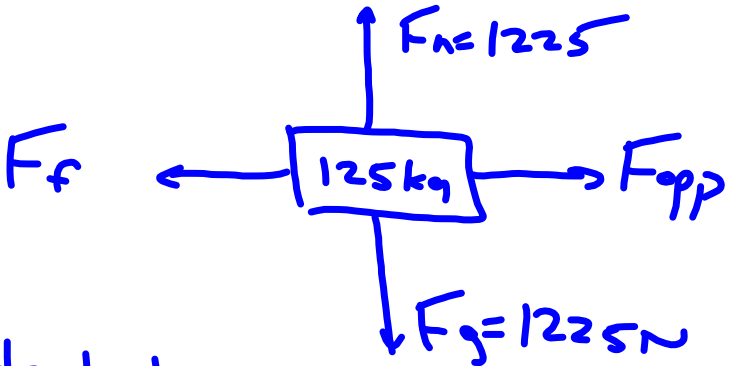
Since $a = 0$, $F_{app} = F_{fk}$ ($F_{net} = ma = 0$)

$F_{fk} = 50N$

$$\mu_k = \frac{F_{fk}}{F_n} = \frac{50N}{78.4N} = 0.64$$

Practice Problems (cont'd)

2. A 125kg block of steel is being pushed across a wooden floor. If the coefficient of static friction (μ_s)is 0.45 and the coefficient of kinetic friction (μ_k)is 0.25 calculate the minimum force required to get the steel block moving and the force required to keep it moving once it is moving at a constant speed.



- to start it moving.

$F_{app} = F_{fs}$

$= \mu_s F_n$

$= 0.45 \times 1225N$

$= 551N$

- to keep it moving

$F_{app} = F_{fk}$

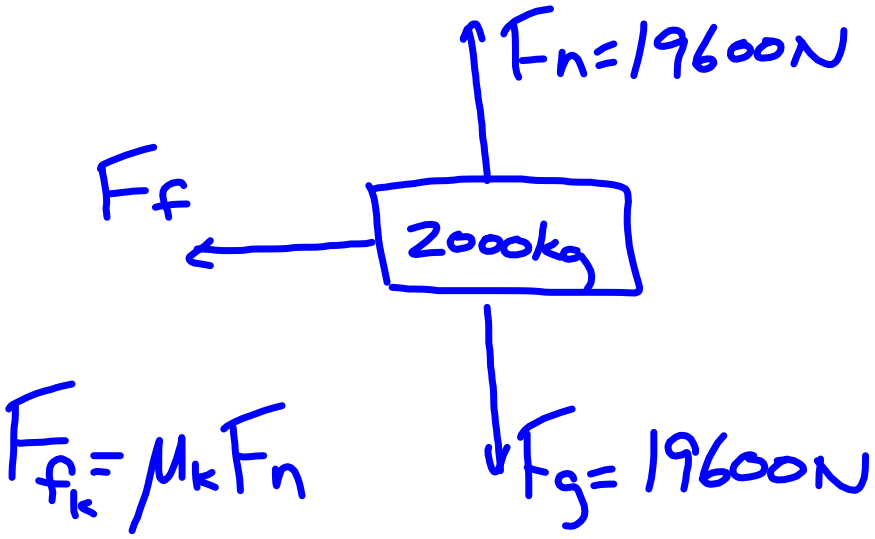
$= 0.25 \times 1225N$

$= 306N$.

∴ to start the object moving requires 550N of force & to keep it moving requires 310N of force.

Practice Problems (cont'd)

3. The driver of a 2.00×10^3 kg car applies the brakes on a dry concrete roadway. Calculate the force of friction between the tires and the road surface if $\mu_k = 1.02$.



$F_{f_k} = \mu_k F_n$

$= 1.02 \times 19600\,N$

$= 19992\,N$

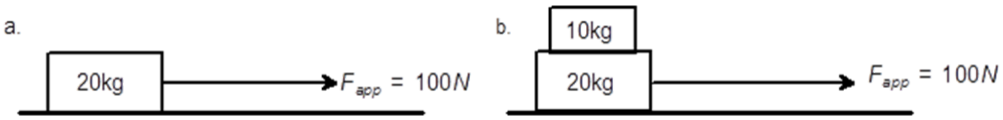
$= 2.0 \times 10^4\,N$

Practice Problems (cont'd)

4. A 20 kg box is dragged across a level floor with a force of 100N. The coefficient of kinetic friction between the box and the floor is 0.32 and the coefficient of static friction is 0.45.

a. Will the box start moving and if so what is the acceleration?

b. If a 10 kg weight is added to the box, will the 100N be enough to start the box moving and if so what is the acceleration?



a.

$F_n = 196N$

F_f ← 20kg → $F_{app} = 100N$

$F_g = 196N$

- will it move

$F_{fs} = \mu_s F_n$

$= 0.45 \times 196N$

$= 88N$

Since $F_{app} > F_{fs}$ it will move.

- moving

$F_n = 196N$

63N ← F_{fk} | → $F_{app} = 100N$

F_g 196N

$F_{fk} = \mu_k F_n$

$= 0.32 \times 196N$

$= 63N$

$F_{net} = F_{app} - F_{fk}$

$= 37N$

$a = F_{net}/m$

$= 37N/20kg$

$= 1.9 m/s^2$

b. $F_g = 294N$

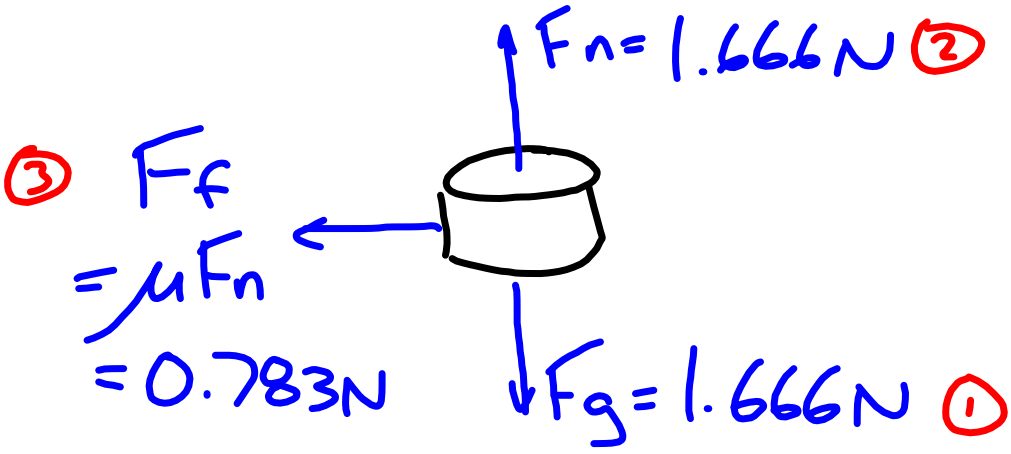
$F_n = 294N$

$F_{fs} = 132N$

∴ it won't move

$(F_{app} < F_{fs})$

5. A 0.170 kg hockey puck is travelling at 19m/s when it strikes a rough patch of ice with a coefficient of kinetic friction (μ_k)equal to 0.47. How far will the puck travel before it stops on this rough ice?



$$a = F_{net}/m = 0.783N/0.170kg$$
$$= 4.61 m/s^2$$

$a = -4.61 m/s^2$

$V_1 = 19 m/s$

$V_2 = 0$

$\Delta d = ?$

$$\Delta d = \frac{V_2^2 - V_1^2}{2a}$$
$$= 39m$$