Checkup on Previous Learning

Universal Gravity
- 2 body problem
- Apollo 13 problem

Friction activity feedback

Today's Plan

Friction Lesson

Problem Solving with Friction

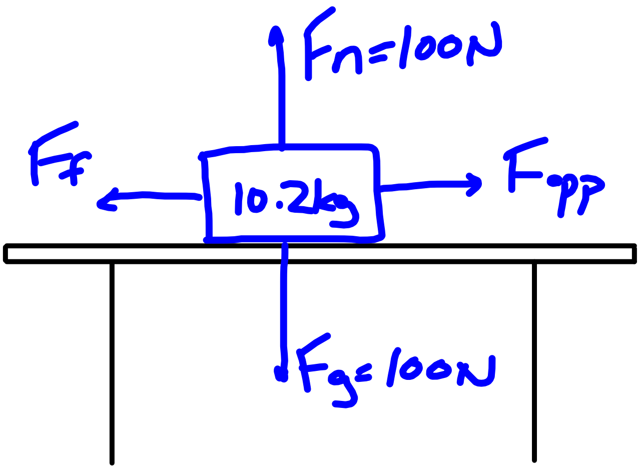
Coming Up

Complete Friction

Unit Review - Nov 9th

Unit Test - Nov 13th

Friction



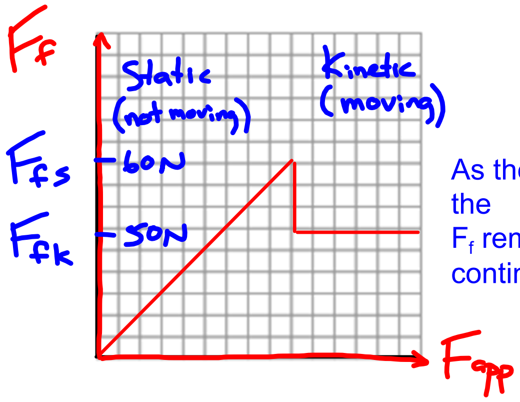
$F_g = mg$
$= 10.2 \times 9.8$
$= 100N$

The force of friction depends on two things:

1. normal force
2. type of materials interacting

Friction Summary Notes

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.

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.

F_{fk} → ongoing frictional force that opposes motion

coefficient of static friction	coefficient of kinetic friction
→ defined at point of maximum static frictional force	→ defined using ongoing kinetic frictional force.
$\mu_s = \frac{F_{fs}}{F_n}$	$\mu_k = \frac{F_{fk}}{F_n}$

in our example:

$F_n = 100N$

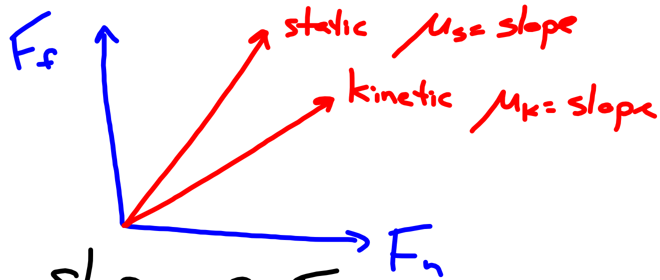
$F_{fs} = 60N$

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

$F_n = 100N$

$F_{fk} = 50N$

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



Slope of F_f vs F_n graph = coefficient of friction

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

$$\mu_s = \frac{F_{fs}}{F_n} \qquad \mu_k = \frac{F_{fk}}{F_n}$$

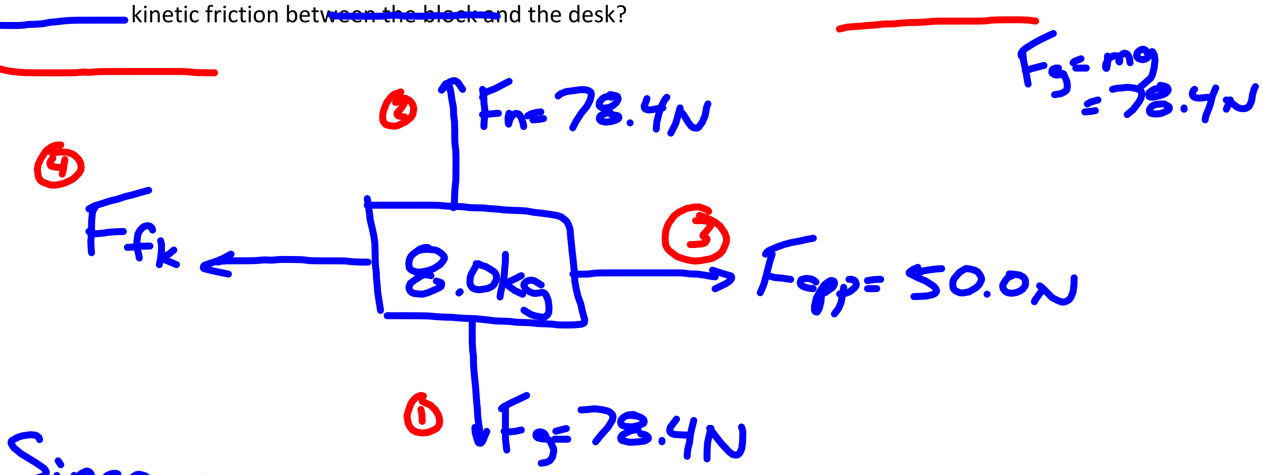
$$F_{fs} = \mu_s F_n \qquad F_{fk} = \mu_k F_n$$

force required to start an object moving.

force opposing motion for a moving object.

Sample 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 $a = 0$, $F_{app} = F_{fk}$

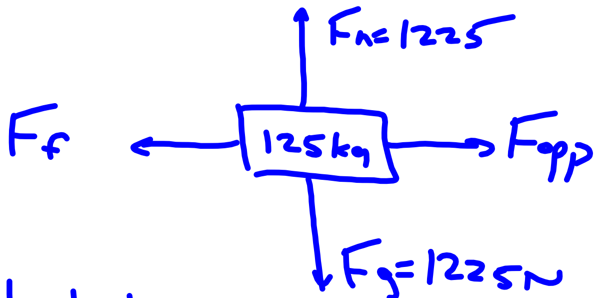
$F_{fk} = 50N$

$(F_{net} = ma = 0)$

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

Sample 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

$F_{app} = F_{fk}$

$= 0.25 \times 1225N$

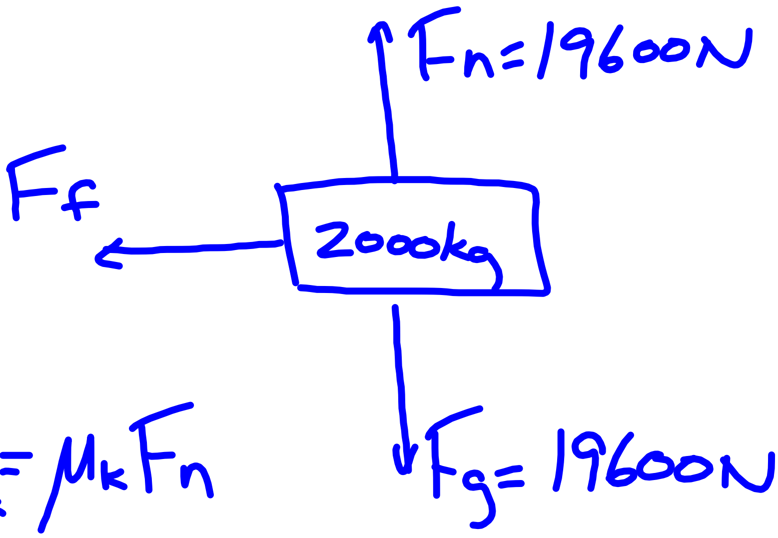
$= 306N$.

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

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.

Sample 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 $\mu_k = 1.02$.



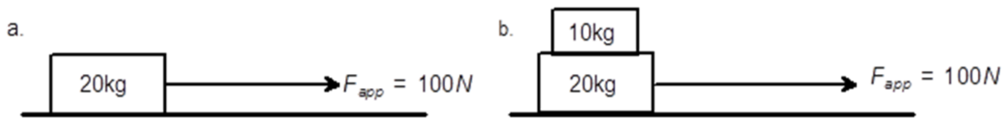
$$F_{f_k} = \mu_k F_n$$
$$= 1.02 \times 19600\,N$$
$$= 19992\,N$$
$$= 2.0 \times 10^{4}\,N$$

Sample Problems (cont'd)

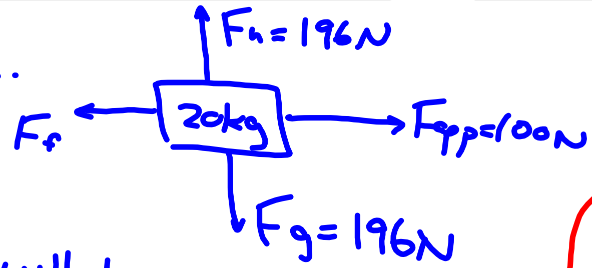
4. A 20 kg box is dragged across a level floor with a force of 100N. The coefficient of kinetic friction between the box and the floor is 0.32 and the coefficient of static friction is 0.45.

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.



• will it move

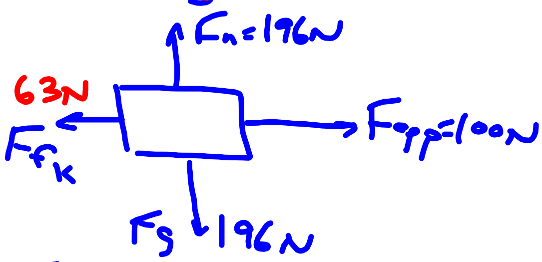
$F_{fs} = \mu_s F_n$

$= 0.45 \times 196N$

$= 88N$

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

• moving



$F_{fk} = \mu_k F_n$

$= 0.32 \times 196N$

$= 63N$

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

$= 37N$

$a = F_{net}/m$

$= 37N / 20kg$

$= 1.9 m/s^2$

b. $F_g = 294N$

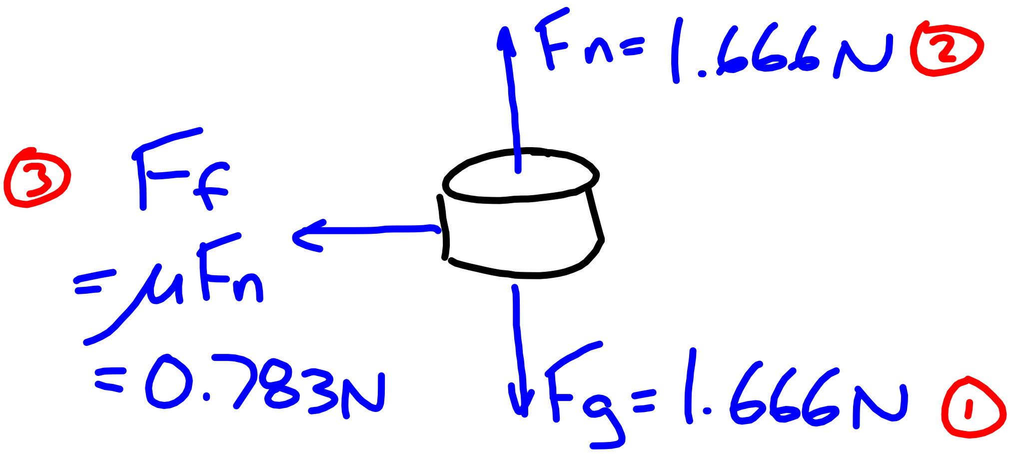
$F_n = 294N$

$F_{fs} = 132N$

∴ 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?



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

$a = -4.61\ m/s^2$

$V_1 = 19\ m/s$

$V_2 = 0$

$\Delta d = ?$

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

Checkup on Previous Learning

Friction problems review

Today's Plan

Working with experimental data

Problem Solving with Friction

Coming Up

Unit Review - tomorrow - Nov 9th

Unit Test - Nov 13th

Working with Experimental Data

1. For the following experimental results - calculate the coefficients of static and kinetic friction
2. Using the table of coefficients of friction, predict what materials may be used.

Surface	Object	Mass of Object (kg)	F_n (N)	F_{fs} (N)	F_{fk} (N)	μ_s	μ_k	Possible Materials
1	A	0.24	2.4	0.96	0.72	0.41	0.31	
1	B	0.36		1.5	1.1			
1	C	0.48		1.9	1.4			
1	D	0.6		2.3	1.7			
2	E	1.2		1.8	1.4			
3	F	1.2		7.1	4.8			
4	G	86		9.3	8.4			
5	H	0.86		5.4	4.2			

3. Assuming Objects A,B,C,D are the same material, plot a graph of the kinetic friction as a function of normal force.
4. Calculate the slope of this line. What does the slope represent?
5. Predict the frictional force on a 10kg and 25 kg object (assuming the same objects as A,B,C,D)

Friction Summary Notes

Working with Experimental Data

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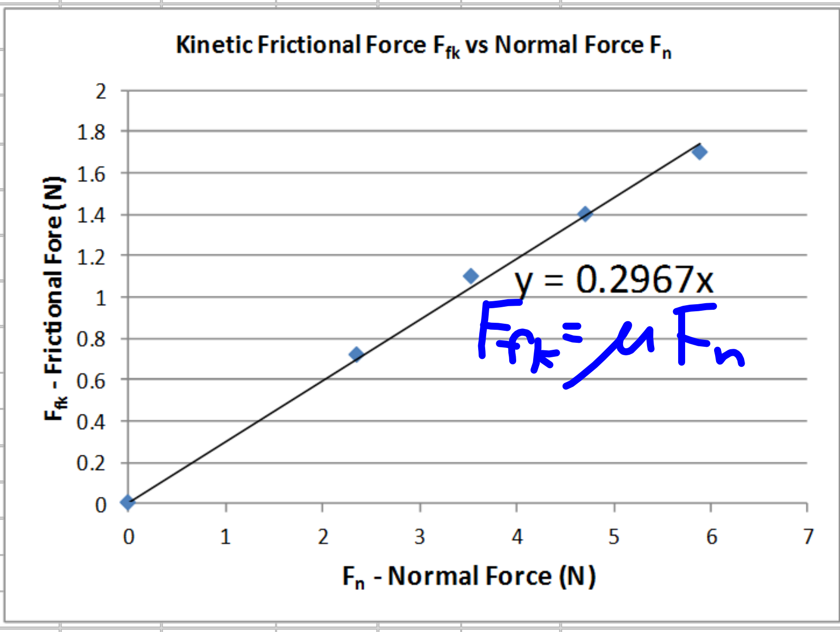
Surface	Object	Mass of Object (kg)	F_n (N)	F_{fs} (N)	F_{fk} (N)	μ_s	μ_k	Possible Materials
1	A	0.24	2.4	0.96	0.72	0.41	0.31	steel on wood
1	B	0.36	3.5	1.5	1.1	0.43	0.31	"
1	C	0.48	4.7	1.9	1.4	0.40	0.30	"
1	D	0.6	5.9	2.3	1.7	0.39	0.29	"
2	E	1.2	11.8	1.8	1.4	0.15	0.12	steel on steel, greasy
3	F	1.2	11.8	7.1	4.8	0.60	0.41	steel on steel dry
4	G	86	843	9.3	8.4	0.011	0.010	teflon on teflon
5	H	0.86	8.4	5.4	4.2	0.64	0.50	aluminum on steel

3. Assuming Objects A,B,C,D are the same material, plot a graph of the kinetic friction as a function of normal force.
4. Calculate the slope of this line. What does the slope represent?
5. Predict the frictional force on a 10kg and 25 kg object (assuming the same objects as A,B,C,D)

$F_n = 98N$ $F_n = 245N$

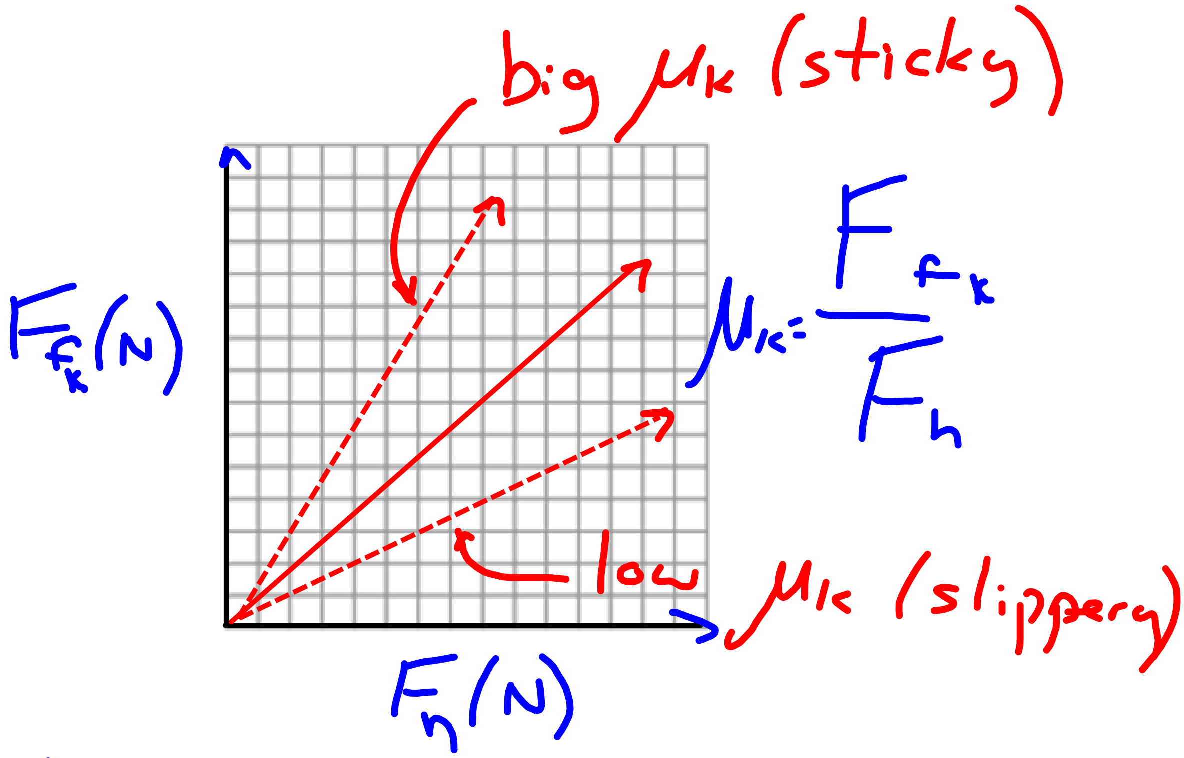
F_n (N)	F_{fk} (N)
0	0
2.352	0.72
3.528	1.1
4.704	1.4
5.88	1.7
98	
245	



Question #5

mass = 10 kg	Fn=98N	F_{fk}=29N
mass = 25 kg	Fn=245N	F_{fk}=74N

Coefficient of Kinetic Friction - a closer look



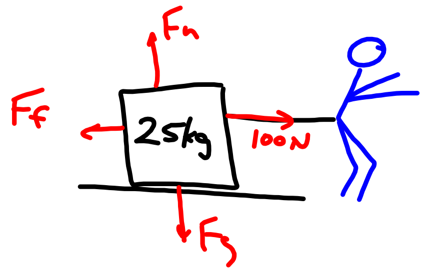
$$\mu_k = \frac{F_{f_k}}{F_n}$$

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

Friction : Practice Problems

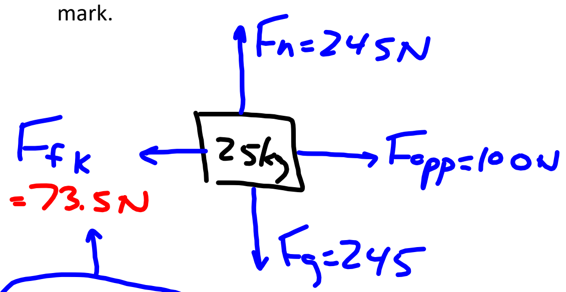
Some sprinters use a weight to help in training for sprint races. A strap is attached to a block and then dragged behind the sprinter. In this example a 25 kg block is used. The coefficient of static friction (μ_s) is 0.40 and the coefficient of kinetic friction is (μ_k)is 0.30 between the block and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

1. 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
($F_{app} > F_{fs}$)

   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.



$F_{fk} = \mu_k F_n$
$= 73.5N$

$F_{net} = 100 - 73.5$
$= 26.5N$

$a = F_{net}/m$
$= 26.5N/25kg$
$= 1.06 m/s^2$

$a = 1.06 m/s^2$
$V_1 = 0 m/s$
$\Delta d = 20m$
$\Delta t = ?$

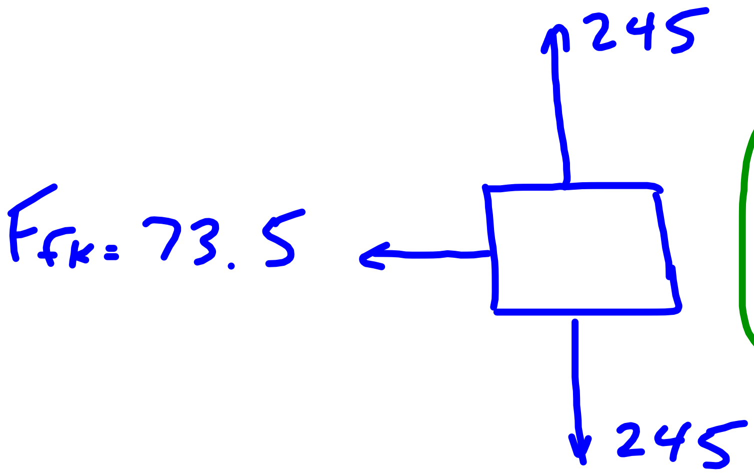
use eqn ③

$\Delta d = V_1 \Delta t + \frac{1}{2} a \Delta t^2$
$\Delta t = 6.14s$

to find V_2 use eqn ⑤
$V_2 = 6.5 m/s$

2. At the end of the 20m the sprinter releases the strap and allows the block to coast to a stop.

a. How long (in seconds) and how far does the block travel before stopping?



F_f is the only horizontal force acting on the block $\therefore F_{net} = F_f$

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

$v_1 = 6.5\ m/s$

$a = -2.94\ m/s^2$

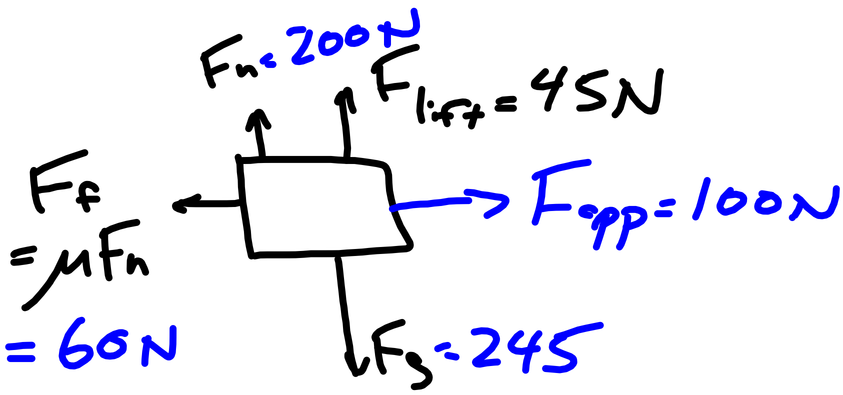
$v_2 = 0$

$\Delta d = 7.2\ m$ (5)

$\Delta t = 2.2\ s$ (2)

3. In this example a balloon is attached to the block to “lighten“ the load. The lift provided by the balloon is 45N.

a. 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)