Physics G

Force

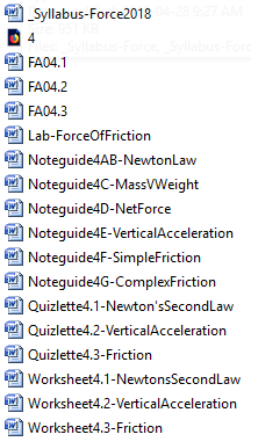
(Chapter 4 Syllabus)

Block	In Class	Due on this class
1 Dec 12/13	**DI**-Unwise/Demos **GW**-4.1 Newton's Second Law QL **DI**-Newton's Third Law ILDs	**VF 4AB, 4C**
2 Dec 16/17	**GW**-Newton's Second Law QL **GW**-FA4.1 **DI**-Newton's 2nd law ILDs	Turn In: Newton's Second Law QL
3 Dec 18/19	**SA4.1 Newton's Second Law (first 30)** **VF**-4D More than one force **DI**-Net Force	Turn In: FA4.1 - Newton's Second law
4 Dec 20/ Jan 6	**DI**-Unwise/Elevators/Force Plate ILDs **GW**-4.2 Vertical Acceleration QL	**VF 4D, 4E Vertical Acceleration**
5 Jan 7/8	**GW**-4.2 Vertical Acceleration QL **GW**-FA4.2 Vertical Acceleration	Turn In: Vertical Acceleration QL
6 Jan 9/10	**SA4.2 Vertical Acceleration (first 30)** **VF**-4F Simple Friction **DI**-Friction demos/Static/Kinetic/4G	Turn In: FA4.2 - Vertical Acceleration
7 Jan 13/14	**DI**-The Friction Lab/ Racetrack Game/HW assg **GW**-4.3 Friction Quizlette **GW**-Friction QL/Racetracks/Lab/FA4.3	**VF 4F, 4G Friction Problems**
8 Jan 15/16	**IW**-Friction Lab **GW**-Friction Lab	
9 Jan 17/21	**SA4.3 Friction (first 30)** **GW**-Friction Lab **VF**-7A, 7B	Turn In: FA4.3 Friction Turn In: Friction Lab Turn in: P4.3 #1-3, 0-d Turn in: Racetracks Turn In: 4.3 Friction QL
	Final	Turn In: Mock Final (EC)
Jan 28/29	**Circular Motion!!**	**VF 7A, 7B - Centripetal**

Assignments:

- 2 Labs:
  - *Racetrack* lab – 3 Races with other people /15 pts
  - *Force of Friction* lab – Groups of 2 /40 pts
- 3 in-class Quizlettes - group work (10 pts each)
  - 4.1 Newton's Second Law Quizlette
  - 4.2 Vertical Acceleration Quizlette
  - 4.3 Friction Quizlette
- 1 Homework Assignment:
  - P4.3 #1-3, 0-d /10 pts
- 3 Formative/Summative Assessments: (10 pts each)
  - 4.1 - Newton's Second Law
  - 4.2 - Vertical acceleration
  - 4.3 - Friction

Handouts:



Noteguide for Newton's Laws - Videos 4A, 4B (keep) **Name**_____

Write down the laws:

1

2

3

$$F = ma$$

Example: What force causes a 4.0 kg object to accelerate at 6.0 m/s/s?
(Write down as well the base units of a Newton)

Example: A 2.1 kg hammer accelerates from rest under the influence of a net force of 120 N. What is its final velocity if the force is exerted over a distance of 78 cm

(Whiteboards on the back)

Try these example problems. If you can't get the answer on your own watch the video. Use your calculator.

1. What unbalanced force causes a 892 g object to accelerate at -9.81 m/s/s? (-8.75 N)	2. What is the acceleration of a 12 kg object if you exert 37 N of unbalanced force on it? (3.1 m/s/s)
3. What is the mass of an object if when there is a 128 N net force acting on it, it accelerates at 3.7 ms^{-2}? (35 kg)	4. A 16 kg object going 23 ms^{-1} is stopped by a force in 0.125 s. What force? (-2944 N)
5. A 3.84 kg object going 42.0 ms^{-1} experiences a force of -23.5 N for 2.60 s. What is the final velocity of the object? (26.1 m/s)	6. A 143 gram baseball going 39 m/s caught by the catcher. In stopping, the baseball travels 7.5 cm. What is the average force exerted on the ball? (-1450 N)

Noteguide for Mass vs. Weight - Videos 4C (keep) **Name**_____

Mass

Weight

Example: What is the weight of a 5.0 kg mass on earth?

Try these example problems. Don't freak out if you can't immediately get the answer. We will work on these as a group in class. They are solved in the linked videos that follow the main one

1. What is the weight of a 20.3 gram European Swallow? (0.199 N)	2. What is the mass of an object that weighs 582 N on earth? (59.3 kg)
3. A 62.0 kg person weighs 101 N on the moon. What is the moon's "g"? (1.63 N/kg)	

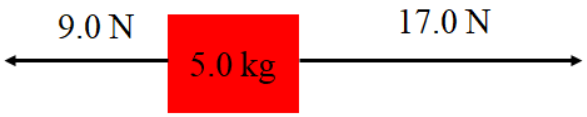
Noteguide for Net Force - Videos 4D (keep) **Name**_____

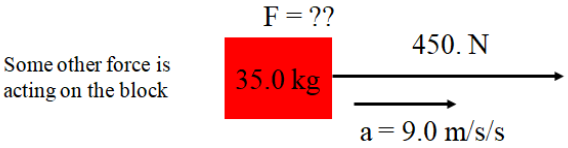
Steps:

1.

2.

3.





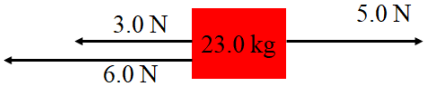
Try these example problems. If you don't get the answer, watch the video to see how.

Find the acceleration:

1. 

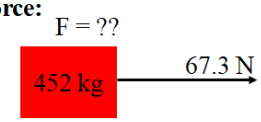
(0.80 m/s/s)

Find the acceleration:

2. 

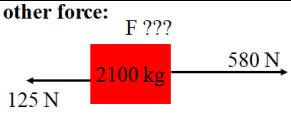
(-0.17 m/s/s)

Find the other force:

3. 

a = 0.12 m/s/s to the right (-13 N)

Find the other force:

4. 

a = 0.15 m/s/s to the left (-770 N)

Noteguide for Vertical Acceleration - Videos 4E (keep) **Name**_____

Example 1

A 5.0 kg mass hangs on a string with a tension of 65 N. What is the acceleration of the mass?

Example 2

A 510 kg elevator accelerates downwards at 1.5 m/s/s. What is the tension in the cable supporting it?

Example 3

A 1350 kg elevator moving downwards at 5.31 m/s arrests its motion in 2.10 seconds. What is the tension in the elevator as it stops?

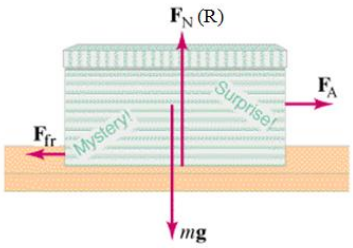
(Do the whiteboards on the back)

Try to do these without looking at the video, but if you get stuck, watch the video until you get unstuck, and do it from there.

1. A 314 kg elevator accelerates upward 4.7 m/s/s. What is the tension in the cable supporting it? (4553 N)	2. A 314 kg elevator accelerates downward at 2.7 m/s/s. What is the tension in the cable supporting it? (2229.4 N)
3. A 10.0 kg mass hangs on a string with a tension of 126 N, what is its acceleration? (+2.8 m/s/s upwards)	4. A 10.0 kg mass hangs on a string with a tension of 52.0 N, what is its acceleration? (-4.6 m/s/s downwards)
5. A 62 kg climber falling at 9.4 m/s has their downward motion arrested in a distance of 5.3 m. What is the tension on the rope if the acceleration is uniform? (1124.4 N)	6. A 1420 kg elevator is moving upwards at 4.1 m/s and stops in 1.7 s. What is the tension in the cable supporting the elevator as it stops? (10,491.3 N)

Friction Noteguide Videos 4F **(keep)** **Name**_____

Friction - Force needed to drag one object across another. (At a constant velocity):



Depends on:

Not supposed to depend on:

Table from the book:

TABLE 4–2 Coefficients of Friction†

Surfaces	Coefficient of Static Friction, μ_s	Coefficient of Kinetic Friction, μ_k
Wood on wood	0.4	0.2
Ice on ice	0.1	0.03
Metal on metal (lubricated)	0.15	0.07
Steel on steel (unlubricated)	0.7	0.6
Rubber on dry concrete	1.0	0.8
Rubber on wet concrete	0.7	0.5
Rubber on other solid surfaces	1–4	1
Teflon® on Teflon in air	0.04	0.04
Teflon on steel in air	0.04	0.04
Lubricated ball bearings	<0.01	<0.01
Synovial joints (in human limbs)	0.01	0.01

†Values are approximate and are intended only as a guide.

Kinetic Friction - Force needed to **k**eep it going at a constant velocity. (AKA Kinetic friction)

$F_F = \mu_k F_N$

Always in opposition to velocity (direction it is sliding)

Static Friction - Force needed to **st**art motion.

$F_F \leq \mu_s F_N$

Keeps the object from moving if it can.

Only relevant when object is stationary.

Always in opposition to applied force.

Calculated value is a <u>maximum</u>

TABLE 4–2 Coefficients of Friction†

Surfaces	Coefficient of Static Friction, μ_s	Coefficient of Kinetic Friction, μ_k
Wood on wood	0.4	0.2
Ice on ice	0.1	0.03
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Steel on steel (unlubricated)	0.7	0.6
Rubber on dry concrete	1.0	0.8
Rubber on wet concrete	0.7	0.5
Rubber on other solid surfaces	1–4	1
Teflon® on Teflon in air	0.04	0.04
Teflon on steel in air	0.04	0.04
Lubricated ball bearings	<0.01	<0.01
Synovial joints (in human limbs)	0.01	0.01

†Values are approximate and are intended only as a guide.

Try these Whiteboards - watch the video if you can't get them.

1. What force is needed to start to slide a 45.0 block of rubber across dry concrete? (441 N)	2. What force is needed to continue to slide a 32.0 block of wood across a wood floor? (62.7 N)
3. What force is needed to begin sliding a 921 kg block of ice across a frozen lake? What force will it then take to keep it sliding? (903 N, 271 N)	4. What force is needed to begin sliding a 2350 kg car across wet concrete? (16,121 N)
5. What is the mass of ice you have if it takes 12.0 N of force to slide it at a constant speed across ice? (40.8 kg)	6. You have a 2.1 kg block of plastic and it takes you 8.65 N of force to slide it at a constant speed across your Formica table. What is the coefficient of friction? (0.42)

Noteguide for Solving Friction Problems Videos 4G (keep) **Name**_____

Write down the general strategy:

Sample Problem: A 5.00 kg block rests on a level table where there is a static coefficient of friction of 0.470, and a dynamic of 0.170.

a) What are the dynamic and maximum static forces of friction?

b) If it is at rest and you exert a force of 12.0 N sideways on it what happens?

c) If it is at rest and you exert a force of 35.0 N to the right on it, what is the acceleration of the block? Is the block accelerating (speeding up) or decelerating (slowing down)?

d) If it is sliding to the right and you exert a force of 7.50 N to the left, what is the acceleration of the block? Is the block accelerating (speeding up) or decelerating (slowing down)?

e) What force is required to make the block slide to the right and accelerate to the right at 6.70 m/s/s? Is the force to the right or the left?

f) If it is sliding to the right, but decelerating at 0.950 m/s/s, what force is acting on the block? Is the force to the right or the left?

P4.1 Newton's Second Law Questions

(Use g = 9.8 m/s/s - round to three digits total)

63.7 N 12.9 m/s/s 16.7 kg 6.51 N 45.9 m/s	1. a. What is the weight of a 6.50 kg object on earth? b. What is the acceleration of a 2.80 kg object of there is 36.0 N of unbalanced force on it? c. What mass on earth weighs 164 N? d. What net force would accelerate a 1.60 kg mass from rest a distance of 17.1 m in 2.90 s? e. A 15.0 N net force acts on a 4.90 kg mass. If it accelerates from rest, what is the final velocity in 15.0 s?
91.9 N 6.68 kg 637 N 292 N 21.8 m	2. a. What net force would accelerate a 37.5 kg mass at 2.45 m/s/s? b. What mass accelerates at 2.98 m/s/s when a force of 19.9 N acts on it? c. What is the weight on earth of a 65.0 kg boy named Brennen? d. A 58.2 kg mass accelerates from 5.70 m/s to 25.3 m/s in 3.90 s. What net force acted? e. A net force of 46.7 N acts on a 8.80 kg mass. What distance has it covered from rest when it has reached a speed of 15.2 m/s?
65.3 kg 57.6 N 14.5 kg 10.1 s 47.0 N	3. a. What mass on earth weighs 640. N? b. What net force would accelerate a 18.0 kg mass at 3.20 m/s/s? c. What mass would accelerate at 5.30 m/s/s when there is a net force of 77.0 N acting on it? d. A net force of 12.5 N acts on a 2.80 kg mass. After what time would the mass reach a speed of 45.0 m/s from rest? e. A 7.20 kg mass accelerates from 4.10 m/s to 17.8 m/s over a distance of 23.0 m. What net force acted?
2.22 kg 22.0 N 0.704 m/s/s 27.3 N 17.3 m	4. a. What mass accelerates at 8.75 m/s/s when there is a net force of 19.4 N acting on it? b. What is the weight of a 2.24 kg object on earth? c. What is the acceleration of a 6.12 kg mass if there is a net force of 4.31 N acting on it? d. A 5.10 kg mass accelerates from rest to a speed of 23.8 m/s in a distance of 53.0 m. What net force was needed? e. A net force of 14.7 N acts on a 5.80 kg mass. What will be its displacement from rest if it accelerates for 3.70 s?
0.788 m/s/s 4.29 kg 5.925 N 3.14 s 102 N	5. a. What is the acceleration of a 17.0 kg mass if there is a net force of 13.4 N acting on it? b. What mass weighs 42.0 N on earth? c. What net force would accelerate a 1.50 kg mass at 3.95 m/s/s? d. A net force of 47.0 N acts on a 16.5 kg mass. In what time will it cover a distance of 14.0 m from rest? e. A 47.0 kg mass accelerates from 3.90 m/s to 12.8 m/s in 4.10 s. What net force acted?

P4.2 Vertical Acceleration Questions

Use the convention that up is positive. The assessments will have each only one problem with kinematics.

+96.1 N +44.9 N +10.8 m/s/s +85.0 N -35.1 m	**1. A 6.32 kg flour baby hangs on a cord.** a. What is the tension in the cord if the flour baby is accelerating upwards at 5.40 m/s/s? b. If the flour baby is accelerating downwards at 2.70 m/s/s, what is the tension in the cord? c. If the tension in the cord is 130. N, what is the acceleration of the flour baby? d. If the flour baby is moving downwards at 5.50 m/s, and stops in 1.51 s, what was the tension in the cord during this time? e. There is a tension in the cord of 40.0 N. If the flour baby is initially at rest, what is the displacement of the flour baby 4.50 s later?
+32.5 m/s/s +19.5 N +9.82 N +3.60 N 1.20 s	**2. A 1.30 kg giant gerbil hangs on a cable.** a. If the upward force exerted by the cable is 55.0 N, what is the acceleration of the giant gerbil? b. What tension in the cable would cause the giant gerbil to accelerate upwards at 5.20 m/s/s? c. What is the tension in the cable if the giant gerbil has a downward acceleration of 2.26 m/s/s? d. The giant gerbil accelerates from rest to a downward velocity of 9.56 m/s in a distance of 6.50 m. What was the tension in the cable as it was doing this? e. There is a tension of 32.0 N in the cable. In what time can the giant gerbil change its velocity from rest to 17.8 m/s upwards?
+29.7 N +5.58 m/s/s +84.6 N +28.4 N +6.37 m/s	**3. A 5.20 kg baby koala hangs from a rope.** a. What is the tension in the rope if the koala is accelerating downwards at 4.10 m/s/s? b. If the tension in the rope is 80.0 N, what is the acceleration of the koala? c. What tension in the rope would effect an upward acceleration of 6.45 m/s/s? d. From rest, the koala displaces itself downward 7.20 m in 1.82 s. What is the tension in the rope as this is happening? e. If there is a tension of 58.0 N in the rope, what is the final velocity of the koala when it has risen 15.0 m if the koala started from rest?
-2.07 m/s/s +8.60 N +53.9 N +37.4 m/s +7.17 N	**4. A 2.20 kg giant cockroach rappels on a very strong string.** a. What is the acceleration of the cockroach if the tension in the string is 17.0 N? b. If the cockroach is accelerating downwards at 5.90 m/s/s, what is the tension in the string? c. What tension in the string would cause an upward acceleration of 14.7 m/s/s? d. If the tension in the string is 38.0 N, and the cockroach is initially at rest, what is the final velocity of the cockroach after 5.00 s? e. The cockroach is moving upwards at 6.45 m/s and stops in a distance of 3.18 m. What is the tension in the string as he is stopping?
+55.9 N -3.50 m/s/s +16.7 N -11.6 m +72.3 N	**5. A 4.60 kg gourd hangs on a cord.** a. What is the tension in the cord if the gourd is accelerating upwards at 2.35 m/s/s? b. What is the acceleration of the gourd if the tension in the cord is 29.0 N? c. If the gourd is accelerating downwards at 6.19 m/s/s, what is the tension in the cord? d. If the gourd starts from rest, and the tension in the cord is 28.0 N, what is the displacement of the gourd in 2.50 s? e. If the gourd accelerates from an upward velocity of 1.12 m/s to 6.57 m/s in a distance of 3.54 m, what is the tension in the cord?

P4.3 Physics - Friction Questions

Use the convention that to the right is positive, and to the left is negative.
Label every force **right** or **left**; Label every acceleration as either **accel** - speeding up or **decel** - slowing down
Part e from every question is not on the summative assessment, they are there for a challenge (The assessments are like 0. and a. through d.)

7.13 N, 9.68 N Yes: 15.0 N > 9.68 N +2.43 m/s/s (decel) -2.70 m/s/s (decel) -10.0 N (left) -32.6 N (left) +39.7 N (right)	**1. There is a coefficient of kinetic friction of 0.140 and a static of 0.190 between a 5.20 kg box and the level floor.** 0. Calculate the **kinetic friction force**, and the **maximum static friction force**. If the block were at rest, and you exerted a force to the right of 15.0 N, **would the block begin to move**? Support your answer with numbers. a. If the box is sliding to the left, and we exert a force of 5.50 N to the right, what is the acceleration? b. If the box is sliding to the right, and we exert a force of 6.90 N to the left, what is the acceleration? c. The box is sliding to the right, but is decelerating at 3.30 m/s/s, what outside force besides friction is acting on it? d. If the box is sliding and accelerating to the left at 4.90 m/s/s, what force must be acting on it? Optional: e. The box slides from rest to the right reaching a velocity of 14.5 m/s in a distance of 16.8 m. What outside force was acting?
4.89 N, 20.9 N No: 19.0 N < 20.9 N +0.697 m/s/s (accel) +0.461 m/s/s (decel) +25.3 N (right) +28.8 N (right) +6.75 m/s (right)	**2. There is a coefficient of kinetic friction of 0.105 and a static of 0.450 between a 4.75 kg block of wood and the level floor.** 0. Calculate the **kinetic friction force**, and the **maximum static friction force**. If the block were at rest, and you exerted a force to the right of 19.0 N, **would the block begin to move**? Support your answer with numbers. a. If there is a force of 8.20 N to the right, and the block is sliding to the right, what is the acceleration? b. If the block is sliding to the left, and there is a force of 2.70 N to the left, what is the acceleration of the block? c. What applied force would make the block accelerate and slide to the right at 4.30 m/s/s? d. If the block is sliding to the left, but is decelerating at 7.10 m/s/s, what force must be applied to it? Optional: e. If you apply 8.90 N to the right and the block starts to slide to the right from rest, what will be the velocity in 8.00 seconds?
25.4 N, 38.5 N Yes: 45.0 N > 38.5 N -1.48 m/s/s (decel) -4.52 m/s/s (decel) -1.99 N (left) -36.1 N (left) +72.4 N (right)	**3. There is a coefficient of kinetic friction of 0.310 and a static of 0.470 between an 8.35 kg block of wood and the level floor.** 0. Calculate the **kinetic friction force**, and the **maximum static friction force**. If the block were at rest, and you exerted a force to the right of 45.0 N, **would the block begin to move**? Support your answer with numbers. a. If the block is sliding to the right, and there is a force of 13.0 N to the right, what is the acceleration? b. If the block is sliding to the right, but there is a force of 12.4 N to the left, what is the acceleration? c. If the block is sliding to the left, but is decelerating at 2.80 m/s/s, what outside force must be acting? d. If the block is sliding to the right, but is decelerating at 7.36 m/s/s, what is the force acting on the block? Optional: e. From rest the block reaches a speed of 15.0 m/s from rest in a distance of 20.0 m. What force was acting?
4.71 N, 7.90 N No: 6.00 N < 7.90 N -2.87 m/s/s (decel) -0.520 m/s/s (accel) +18.5 N (right) -10.1 N (left) -13.7 N (left)	**4. There is a coefficient of kinetic friction of 0.155 and a static of 0.260 between a 3.10 kg block of wood and the level floor.** 0. Calculate the **kinetic friction force**, and the **maximum static friction force**. If the block were at rest, and you exerted a force to the right of 6.00 N, **would the block begin to move**? Support your answer with numbers. a. If the block is sliding to the right, and you exert a force of 4.19 N to the left, what is the acceleration? b. If the block is sliding to the left, and you exert a force of 6.32 N to the left, what is the acceleration? c. If the block is sliding and accelerating to the right at 4.45 m/s/s, what force must be applied? d. If the block is sliding to the left and accelerating to the left at 1.75 m/s/s, what force must be applied? Optional: e. The block displaces itself to the left 12.0 m from rest in 2.87 s. What force must have acted?
20.4 N, 33.4 N Yes: 34.0 N > 33.4 N +0.778 m/s/s (decel) +1.62 m/s/s (accel) -37.1 N (left) -8.97 N (left) +10.9 m/s (right)	**5. There is a coefficient of kinetic friction of 0.235 and a static of 0.385 between an 8.85 kg box and the level floor.** 0. Calculate the **kinetic friction force**, and the **maximum static friction force**. If the block were at rest, and you exerted a force to the right of 34.0 N, **would the block begin to move**? Support your answer with numbers. a. If the box is sliding to the left, and there is a force of 13.5 N to the left, what is the acceleration? b. If the box is accelerating to the right, and there is a force of 34.7 N to the right, what is the acceleration? c. If the box is sliding to the right, but is decelerating at 6.50 m/s/s, what force must be acting on the box? d. If the box is sliding to the left, but is decelerating at 1.29 m/s/s, what must be the force acting on the box? Optional: e. If the box is sliding to the right, and there is a force of 32.0 N to the right, what will be its final velocity from rest when is has gone 45.0 m?

Physics

The Force of Friction

Sliding friction is a complex force, but we will make some assumptions to make it more manageable. These assumptions are that the force of sliding or static friction does not depend on the speed you are sliding, and that it is directly proportional to the normal force between the surfaces. The purpose of this lab is to test one of those assumptions.

Here's what to do:

1. Get a 0-5 Newton force scale, a friction block, a slotted weight set, and some paper. Measure and record the mass of the friction block that the masses will rest on.

2. Hold the force scale horizontally, and adjust it so it reads zero. Hook the force scale to the Friction block, and gradually increase the force until it breaks free and starts to slide. Record the maximum force the scale read (Static friction), and the force necessary to make the holder slide at a constant speed along the table (Kinetic friction).

3. Perform step 2 after adding these masses (in grams) to the friction block: (0, 250, 500, 750, 1000)

4. Perform steps 2 and 3 for the block sliding along the table, and again for the block sliding on some paper.

5. Calculate the total weight (Not mass!) of the block and added masses for each different amount in Newtons. (i.e., block , block + 250 grams, block + 500 grams...) Don't forget to convert grams to kilograms!

6. For each of the trials above (all 20 of them) compute the coefficient of friction. ($F_f = \mu W$ where μ is the coefficient, W the weight, and F_f the force of friction)

7. Make two graphs of **force** (not the coefficient) of friction (vertical) vs. **weight** (horizontal) one for the paper data and one for the table data. Use a different type of point or different color ink for the two types of friction, the starting or maximum force (Static), and the sliding force (Kinetic). For each set of 5 points, draw a best fit straight line through the points you plot and find the slope of that line. Label each line with its slope. (The slope is the coefficient of friction that corresponds to the series of data)

8. Make sure your lab has the following when you turn it in:
   - A. Your RAW data in a nice data table..
   - B. Your calculated weights (all 5) and Coefficients of friction. (all 20)
   - C. Two graphs, one for each surface type. Each graph should have the following:
     - i. Title, axes labeled, etc
     - ii. A static and kinetic series each fitted with a line whose slope is labeled on the graph itself.
   - D. Write your own answer to the following questions. **Cite data specifically to support any statement you make:**
     - i. How do the static and kinetic friction compare? (Cite specific numbers to support your claim)
     - ii. Come up with a theory as to why they differ as they do (if they do). (Since static friction is measured before the object even accelerates, Newton's first law of motion is **not** applicable)
     - iii. The force of friction obviously must depend on the weight (or more correctly, the normal force), but our formula for friction asserts that this is a linear relationship. Does your data suggest that there is a linear relationship between friction and weight? (Do your data points lie on a straight line, or do they suggest a curve? Do your coefficients of friction stay the same, or is there a trend in them?)