Name: ______________________ Class: __________ Date Due: ________

# Unit 2B Problem Set 1

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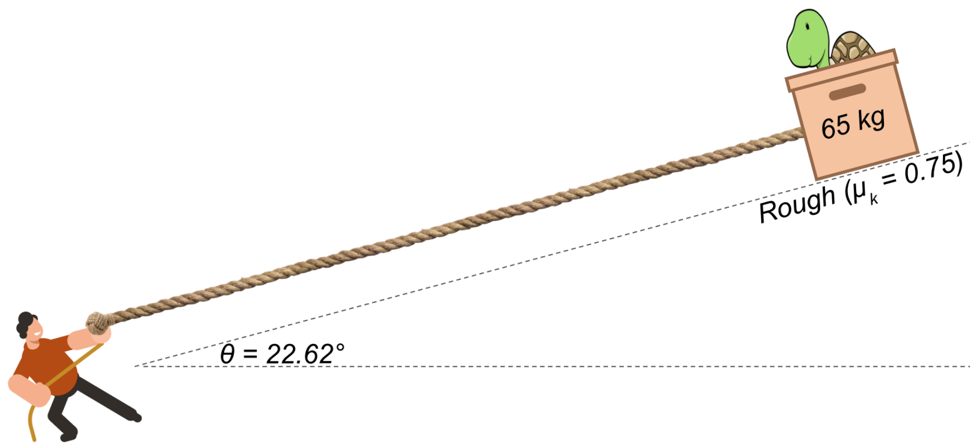
**Criteria For Success**

- ☐ Every question read and marked up on this sheet (you will turn in your solutions on a separate sheet)
- ☐ Each part of each problem is clearly labeled and space to solve is given.
- ☐ Every piece of given information is listed.
- ☐ At least one picture, sketch, diagram, or graph is drawn for the situation and labeled with any given information.
- ☐ A readable attempt has been made to solve each part of each problem.
- ☐ It is apparent where every number comes from.
- ☐ If an equation is used, it is first written without numbers plugged in.
- ☐ Either: an answer is given at the bottom or a quick note is written about what you are stuck on.

Problem 1:

a. Mr. F bought a giant turtle in a box (m = 65 kg) and is trying to pull it home down School Street ($\mu_k$ = 0.75) at a constant speed. How hard would he have to pull?



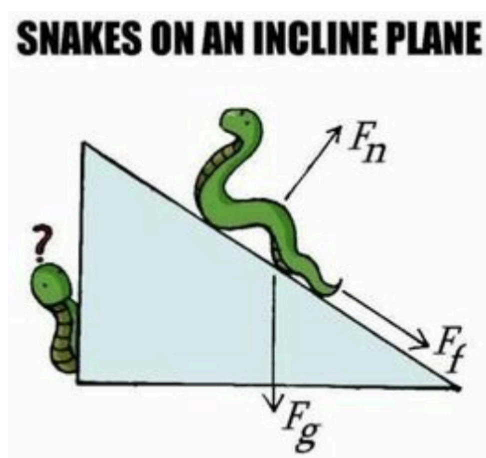

As Mr. F is pulling, he wonders whether this would have been easier if he lived on the moon ($g$ = 1.6 N/kg), but everything else was the same. He reasons the following:

- On one hand, the gravitational force will be smaller, which was helping him, so maybe it will require more force.
- On the other hand, the friction will also be smaller, which was opposing the pulling, so maybe it will require less force.
- Or maybe these two effects cancel out? Mr. F feels very confused :/

b. Explain to Mr. F how much each of the forces will change and why, and whether that will lead to the need to pull with more, less or the same amount of force on the moon. Feel free to use calculations and diagrams as part of your answer.

c. Derive an expression for the tension force in this situation, in terms of $m$, $g$, $\theta$, and $\mu_k$. How does this expression match your reasoning above?

Problem 2: Snakes on an Inclined Plane

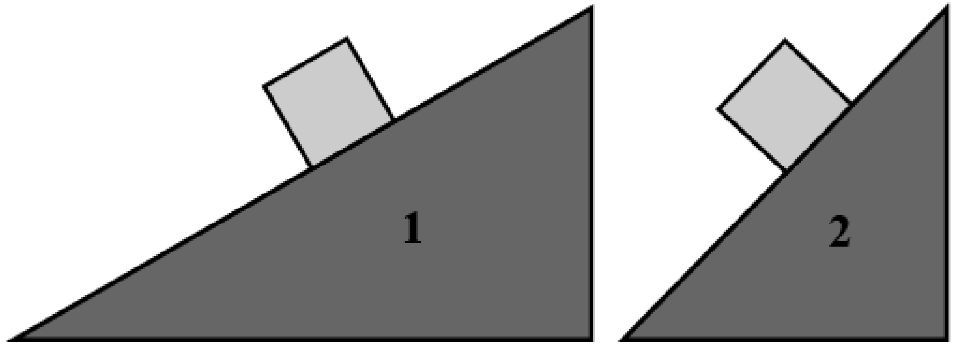



Samuel L. Jackson is tired of all the snakes on the coordinate plane, and kicks one such that it slides up an inclined plane with no force pushing it up the ramp, initially at 3 m/s. The ramp is slippery ($\mu_k$ = 0.1), and inclined at 30°.

a. Show that the snake takes a longer time to travel down the ramp than to travel up the ramp and explain why in terms of the forces acting on it.

b. When the snake reaches the bottom of the ramp, it continues moving on flat ground with the same coefficient of friction. How far does it slide before stopping?

Problem 3: Two blocks start at rest at the same height and slide down frictionless ramps.




a) Multiple Choice:

Which of the following describes the acceleration of these blocks?

A) They both have zero acceleration on the ramp, sliding at constant speed.
B) They have identical accelerations that are increasing.
C) They have constant accelerations on the ramp, but are different from each other.
D) They have increasing accelerations, that are different from each other.

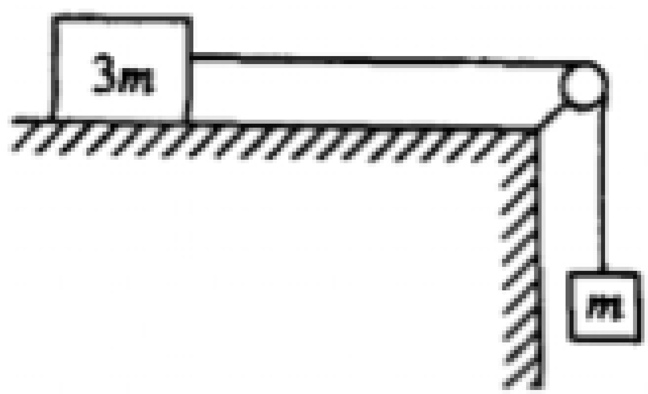
The ramps have these properties:
Ramp 1: Incline angle = 36.87°, 5.00 meters of ramp to slide down.
Ramp 2: Incline angle = 53.13°, 3.75 meters of ramp to slide down.

b) If the blocks start at rest, compare the acceleration, the time to slide done, and the final speed at the bottom. Briefly explain why each is different or the same.

c) How does these results change if the coefficient of friction is changed to $\mu_k = 0.2$?

Problem 4:

Two blocks attached by a light string are released from rest. The hanging block has a mass m, while the block on the frictionless table has a mass 3*m*.




a) Multiple Choice: The tension in the string *T* must be

A) $T < mg$
B) $T = mg$
C) $mg < T < 3mg$
D) $T = 3mg$

Answer the following in terms of *m* and fundamental constants:

b) Determine the acceleration of the hanging mass.
c) Determine the tension in the string.

A student notices that the acceleration of this system is less than they expect and thinks that it is because of friction in the pulley. Assuming that this is true, using free body diagrams for each mass, explain in a few sentences:

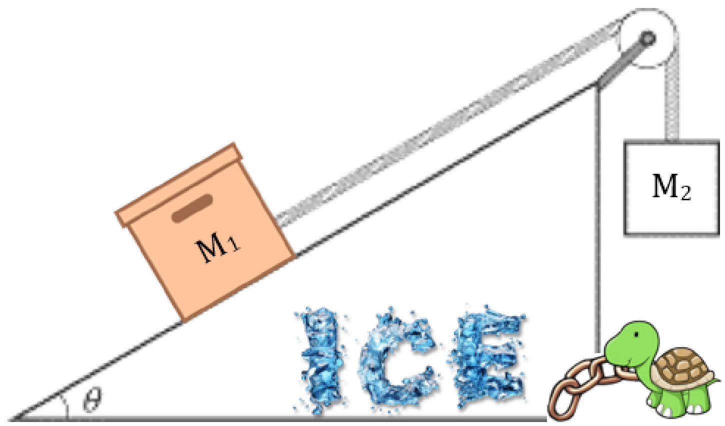
d) whether the tension in the string attached to the hanging block should be more or less than you calculated.
e) whether the tension in the string attached to the block on the table should be more or less than you calculated.

Problem 5: Mr. Freeman comes home one day and finds something terrible! Students have chained his turtle to a triangular prism of ice with incline angle 30°. Two heavy boxes were not moving, one above the turtle.

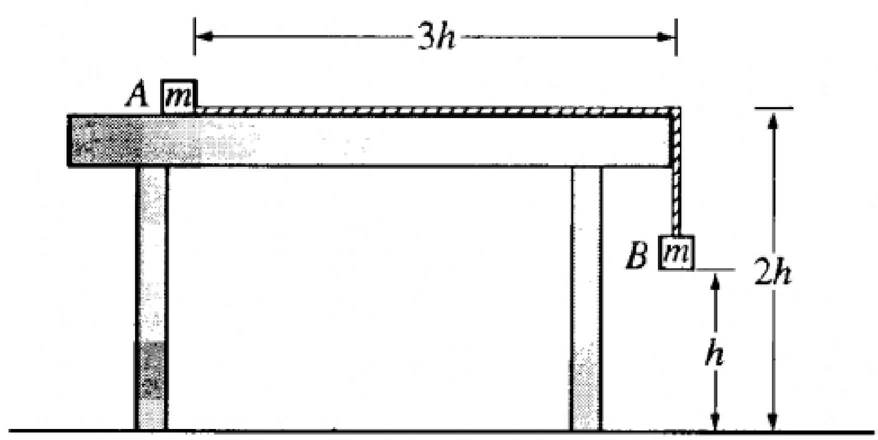
A note on the wall reads:

*Your turtle will be free only if you can tell me the ratio of the two masses ($M_2/M_1$). Otherwise, the ice will melt and your turtle will be no more! Mwahahaha! (Assume friction is negligible. Mwahahaha!)*

Save the turtle.




Problem 6: Two small blocks, each of mass m, are connected by a string of constant length 4*h* and negligible mass. Block A is placed on a smooth tabletop as shown above, and block B hangs over the edge of the table. The tabletop is a distance 2*h* above the floor. Block B is then released from rest at a distance h above the floor at time t = 0.




a) Determine the acceleration of block B as it descends.

b) Determine the speed of block A as it leaves the table. (Assume zero tension in the rope after block B hits the ground.)

c) distance between the landing points of the two blocks.

d) If block A had a mass of 3m, how would your answers to a) and b) change?

e) If this took place on a planet with gravitational constant 3g, how would your answers change?

Hints:

Problem 1:

On your free body diagram there should be 3 forces in the parallel direction: tension, friction, and the downhill component of gravity. Make sure the directions are correct, and balance them since the speed is constant.

Both friction force and downhill component of gravitational force are directly proportional to g, so both will decrease by the same factor. The difference must also decrease by that factor.

Problem 2:

The difference between uphill and downhill is just the direction of friction. Uphill: friction and downhill component of gravity are in the same direction while Downhill: opposite directions. The net force, and thus the acceleration must be greater on the way up since the two forces are working together to stop the snake. The snake therefore stops in a short time, and takes a long time to accelerate down the ramp, since the net force and therefore acceleration is small.

Problem 3:

The acceleration is gsin(theta) in this situation, so only depends on the angle and g. The time will be shorter on the shorter/steeper ramp. However, the final speeds will be the same, since the steeper one accelerates for a proportionally shorter time.

Problem 4: The tension needs to allow the hanging block to accelerate downward.

If the acceleration is less, then the only force that can change here is the tension pulling the blocks. Think about what would need to happen to the tension to make each one slower (it's not the same thing for the two blocks! In this case the friction in the pulley makes the tension different on each side of it, so there will be two different tensions!)

Problem 5

Calculate what the tension must be pulling each block, and set them equal to each other. Then divide by one of the masses so that you've solved for the ratio (written as one divided by the other)

Problem 6

The block turns into a horizontally launched projectile as it leaves the table. Remember: d=vt horizontally, you've solved for the initial horizontal velocity, and the time comes from the vertical direction.