

**State Any Assumptions You Need To Make -- Circle Any Final Answers**  
**Use Your Time Wisely - Work on What You Can - Be Sure to Write Down Equations**  
**Show All Work - Feel Free to Ask Any Questions**

**I'm Inclined To Tell You, That Friction Is A Drag (20,000 points) THIS EXAM FROM SPRING 1995**

1.) A 5.00 kg box is at rest on a  $51^\circ$  inclined plane. (a) Find an appropriate coefficient of friction using the geometry of the incline and explain whether this is the minimum or maximum coefficient to hold the box there.

(b) If the incline had been  $38^\circ$ , and someone had tapped the surface, the box would have slid down the incline at a constant speed. Find an appropriate coefficient of friction using this geometry.

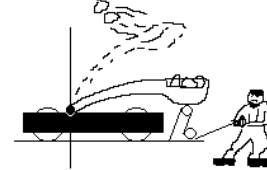
(c) If the 5.00 kg box is dragged 1.00 m up the  $51^\circ$  inclined plane with a 20.0 N force, find the acceleration (if any) of the box.

(d) If the 5.00 kg box is pushed 1.00 m down the  $51^\circ$  inclined plane with a 20.0 N force, find the acceleration (if any) of the box.

(e) What is the speed of the box after being pushed down the  $51^\circ$  inclined plane with a force of 20.0 N for 1.00 m?

**How To Meet Friends And Influence People by Igor The Wretched (20,000 points)**

2.) A small army of barbarians is trying to storm a medium sized castle. They first try to knock down some walls using a catapult. The catapult acts like a large spring. It is pulled back 3.00 m, and holds 125 kg of rocks. The rocks are supposed to fly off at  $30^\circ$  above the horizontal and crash into the castle some 80.0 m away at the same height that are launched at. (a) With what speed do the rocks leave the catapult?



(b) Use conservation of energy to determine the effective spring constant “k” of the catapult.

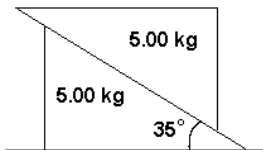
(c) The barbarians use a couple pulleys, as shown above, to pull the catapult down. What force is needed to hold the rope with the catapult loaded and ready to fire?

(d) Unfortunately, due to a design error, the barbarian’s catapult flings the rocks straight up in the air, instead of toward the castle. Use conservation of energy to determine how high the rocks will go.

(e) The barbarians run away before the rocks come back down and *THUD!!* are brought to a stop in 10.0 cm (0.100 m) by the ground. What is the average force that stops the rocks? And how long does it take the rocks to be brought to rest?

**“The Force is Strong in This One.” -- Darth Vader, *Star Wars* (20,000 points)**

3.) Two identical blocks are arranged on a table as shown below. (a) Construct free body diagrams for both blocks, assuming that there is no friction in the problem.

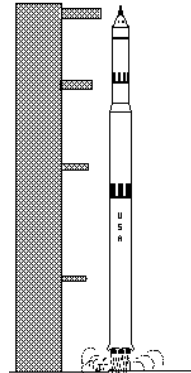


(b) Describe what you think the two blocks will do.

(c) Write down the equations for the forces from the free body diagrams, then (d) try to solve them to find the initial acceleration of each block..

**Apollo 13 The Movie Coming Soon To A Theatre Near You! (20,000 points)**

5.) The mighty Saturn V rocket, which carried Man to the Moon, stood 585 ft. tall (178 m) on the launch pad with a weight of 6.8 million pounds (30,300,000 N). The five giant F-1 engines of the S-I first stage generated a total thrust of seven and a half million pounds (33,400,000 N). (a) What was the initial acceleration of the rocket?



**The first critical time in the mission was when the rocket rose a distance equal to its own height and “cleared the launch tower”, which was within the first 10 seconds after lift-off. (We don’t want to deal with more than a few seconds of the launch, because that would require the “rocket” equation, which is how we deal with the fact that the Saturn V first stage will consume 3,000,000 pounds of fuel in two minutes -- the mass of the rocket could not be considered a constant.)**

(b) Find the work done by the engines on the rocket.

(c) The work done by gravity on the rocket.

(d) Find the change in potential energy of the rocket.

(e) Find the change in kinetic energy of the rocket.