X2.0 107

PHYS-107(13) (Kaldon-20939) **Name** ____________________

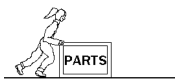
WMU - Spring 2002 **Book Title** ***This is for Topic 1, not your textbook!***
Exam 00 - 000,000 points
Sample – Not a Real Exam

Rev. 5/16/00 Tu · Mod. 5/23/02 Th

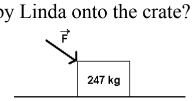
State Any Assumptions You Need To Make -- Show All Work -- Circle Any Final Answers
Use Your Time Wisely - Work on What You Can - Be Sure to Write Down Equations
Short Answers Should Be Short! - Feel Free to Ask Any Questions

"The Force Is Strong In This One." *Darth Vader in Star Wars* (50,000 points)

1.) Linda is shoving a big crate of parts across the shop floor. She is applying a force, F = 100. N, at a standard angle of 320°, and yet the crate is only sliding horizontally and at a constant speed. (a) How do you explain that the motion is only in the horizontal?



(b) How do you explain that v = constant, when there is clearly a force being applied by Linda onto the crate?



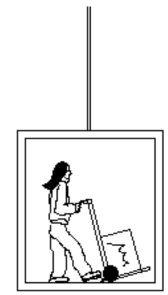
(c) Find the *x*- and *y*-components of the applied force.

(d) The normal force, F_N, is the contact force between the crate and the ground. It is perpendicular to the ground. Since the crate is not moving in the vertical, you can figure out the magnitude of the normal force. *Hint: It is not just equal to the weight of the crate.*

(e) Because the crate is moving at a constant speed, you can easily find the magnitude of the friction force between the floor and the crate, as well as give the standard angle of the friction force.

When It Absolutely Positively Has To Fall (50,000 points)

2.) Jill from FedEx™ is riding the elevator to deliver some packages. (a) If the elevator was accelerating *up*, does Jill feel heavier or lighter? Why?



(b) The loaded elevator has a mass of 500 kg. What is the weight of the elevator?

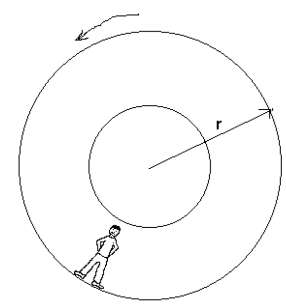
(c) If the elevator is just sitting there, find the force that the *cable* pulls up on the elevator.

(d) If the elevator is accelerating *up* at 2.23 m/s², find the force that the *cable* pulls up on the elevator.

(e) The cable breaks and the elevator falls. What is the *net* vector force on Jill (m = 58.5 kg)?

Round and Round We Go, Where We Stop, Nobody Knows (50,000 points)

3.) Consider a future space station that is rotating to try to provide artificial gravity. Speed is defined as distance/time. (a) Find the speed of the man's feet as they go around and around, if the outside radius of the station is 4.00 m and the station makes one complete revolution every 0.625 seconds.



(b) What is the centripetal acceleration, a_c, of the man's feet?

(c) How does this a_c compare with gravity?

(d) The man's head is 2.00 m above his toes. Find the speed of his head as it goes around and around. *Hint: This will* ***not*** *be the same as in part (a). Why?*

(e) Find the centripetal acceleration of the man's head. Is it very different from the answer in (b)?

A Man With A Hat (50,000 points)

4.) Harold (m = 145 kg) wears a hat (m=0.200 kg). (a) Find the weight of the hat.

(b) Use Newton's Law of Universal Gravity to find the weight of the hat. *$R = 6.40 \times 10^6$ m ; the Earth has a mass of 5.98×10^{24} kg, while $G = 6.67 \times 10^{-11}\ N{\cdot}m^2/kg^2$.*

(c) Find the force of gravity that Harold himself exerts on his hat. *Assume that $r = 1.00$ meters.*

(d) Find the force of gravity that the Moon overhead exerts on his hat. *The distance between the Moon and the Earth is $R = 3.82 \times 10^8$ m, the Moon has a mass of 7.36×10^{22} kg.*

(e) Which is bigger, the answer to (b), (c) or (d)? Which is bigger, the answer to (c) or (d)? Between the answers to (c) and (d), what is the net force acting on the hat?

"Here on the Frozen Tundra of Lambeau Field…" (50,000 points)

5.) One football player, a running back (m_1 = 90.0 kg), is running to the right at 8.00 m/s. A tackle (m_2 = 123 kg), is running to the left at 4.50 m/s. (a) What are their respective momentum vectors, $\vec{p}_1$ and $\vec{p}_2$?

(b) What is the *net* momentum before they collide?

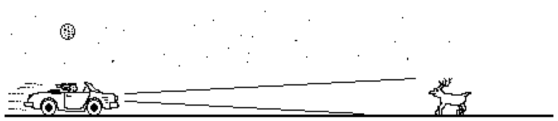
(c) After they collide, with the tackle holding onto the running back, with what speed are they moving?

(d) Show that Kinetic Energy is not conserved in this collision. *Hint: Find the K.E. before and after the collision.*

(e) The football squirts out of the running back's hands 1.20 m above the ground, moving at an unknown upward angle and a speed of 10.7 m/s. With what speed will the football hit the ground? *Use conservation of energy.*

The Deer in the Headlights (50,000 points)

6.) On a beautiful moonlit night, Beatrice is zipping along the highway at 28.0 m/s. Suddenly, 100. m ahead, a dumb deer jumps into the road ("Hey," says Rodney, "I resemble that remark!"). The coefficients of friction for rubber tires on concrete are 0.8 and 1.0. The mass of the car is 1000. kg; the mass of the deer is 200. kg.
(a) Beatrice is so surprised that it is a full two seconds (2.00 sec) before she can stomp on the brake pedal. This is called *the reaction time*. How far is she from the deer before she can hit the brakes?



(b) *If* the wheels were to lock up, and the car were to skid, find the speed of the car just before it hits the deer.

(c) Fortunately for Beatrice, her sports convertible is equipped with ABS (Anti-Lock Braking System), which prevents her wheels from locking up and gives her the maximum braking force. Can she stop before she hits the deer? Find either the distance she misses the deer, or the speed with which she'll hit the deer. *Remember there is still the 2.00 seconds reaction time!*

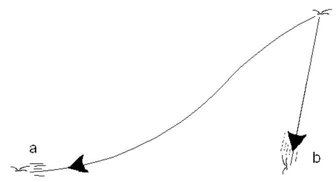
d) Unfortunately for Beatrice, deer often travel in groups, and a second deer jumps right in front of her. There is no time to stop, she hits the deer (which is standing still) at 12.0 m/s. If the deer ends up riding on the hood of her car after the collision, what is the speed of the deer and the car?

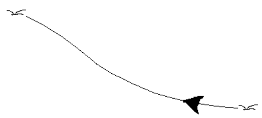
(e) If the pressure in the brake line was 1,000,000 Pa, what height of water column would this pressure represent? $\rho_{water} = 1000\ kg/m^3$.

Bird Droppings (50,000 points)

7.) One of the best-sellers of 1970 was the book Jonathan Livingston Seagull by former U.S. Navy jet pilot Richard Bach. In it, a seagull learns to fly so high and dive so fast that the silly bird went supersonic and found a sort of Zen-like experience through it all. Forgetting all that mushy stuff, and ignoring air resistance as we usually do – (a) Use conservation of energy to figure out how high Jonathan Livingston Seagull (m = 4.84 kg) must fly if he is to reach the speed of sound at $y = 125\ m$. The speed of sound on this day is 343 m/s, assume that $v_{0x} = v_{0y} = 0$.

(b) Jonathan Livingston Seagull can take one of two paths, **a** or **b**, as shown. If bird starts from the same height, is there any difference in the speed that the bird reaches at $y = 125\ m$ at the bottom of the two paths?





(c) The bird flies up from $y = 125\ m$ to $y = 855\ m$. How fast is the bird going now?

(d) Suppose the bird flew into the ground at $v = 343\ m/s$. This would be best described as a *total inelastic collision*. The mass of the Earth is $5.98 \times 10^{24}\ kg$. Find v_{after}.

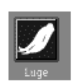
The Luge is a Little Tiny Sled That Careens Down a Track of Ice – It's Insane (50,000 points)

8.) Silke Kraushaar of Germany won the gold medal in Women's Singles Luge in the 1998 Winter Olympics in Nagano, Japan. (a) If the luge run has a vertical drop of 125. meters, then what was Kraushaar's potential energy at the start of the race relative to the finish line? Take her mass to be 65.0 kg.

(b) Using Conservation of Energy to find the *speed*, what would Silke Kraushaar's maximum *momentum* have been at the finish line, assuming that there were no dissipative forces involved?

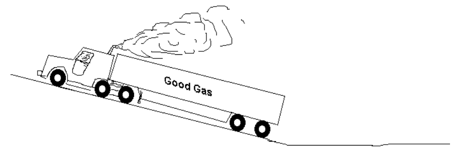
(c) List two reasons why Silke Kraushaar's final speed was *not* as high as your answer in (b). *Note that the fact that the luge track was at an angle, and not a pure vertical drop, is irrelevant to conservation of energy.*

(d) At 70 m.p.h. (31.3 m/s), Silke Kraushaar enters a tight turn and experiences a centripetal acceleration of 3.50 gees (three and a half times that of gravity). Find the radius of this turn.



(e) After four runs, Silke Kraushaar beat her nearest competitor, German teammate Barbara Niedernhuber, by two-thousandths of a second (t = 0.00200 sec). At 70 m.p.h. (31.3 m/s), how big of a distance is that? And is this more or less that the length of her sled (about one meter)?

The Ravine Hills of Death (50,000 points)



9.) A truck weighing 66,000 pounds (m = 30,000 kg) tries to go up a steep hill ($\theta = 20°$) that is covered in sheet ice. The coefficients of friction of rubber tires on ice are 0.15 and 0.20 respectively. Friction does two things here. It provides the force that will move the truck up the hill. And it opposes the motion – the truck would want to slide *down* the hill. (a) Which way does the friction force point?

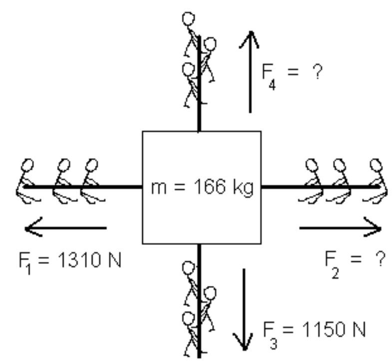
Draw (b) the Free Body Diagram of the truck on the hill.

(c) Prove to yourself that the normal force, F_N, on the truck is equal to the y' component of the weight, which would be $mg \cos \theta$.

The force that would pull the truck down the hill is the x' component of the weight, which is $mg \sin \theta$. Is either (d) static friction or (e) kinetic friction big enough to get the truck up the hill with either good traction or spinning wheels?

Two-Dimensional Tug of War (50,000 points)

10.) Four teams are involved in a tug of war contest as shown below. Note that in this problem x and y are both horizontal directions – the vertical problem is not shown. Team 1 exerts a force of 1310 N in the $-x$ direction. Team 3 exerts a force in the $-y$ direction. If the mass in the center *does not move*, find (a) the forces applied by Teams 2 and 4.



If the mass in the center moves at 0.500 m/s in the $+y$ direction, then find (b) F_2 and (c) F_4.

If the mass in the center accelerates at 0.0500 m/s² @ 45°, then find (d) F_2 and (e) F_4.