

P121 Final Exam (May 10, 2001)

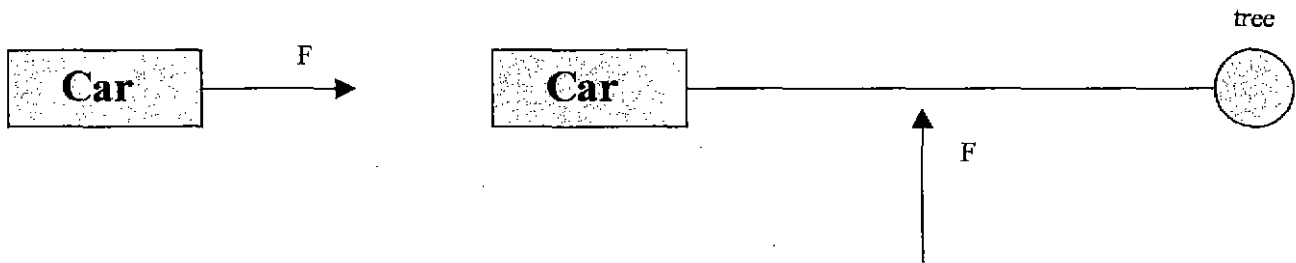
Please read the problems carefully and answer them in the space provided. Write on the back of the page, if necessary. Show all your work. Partial credit will be given.

Problem 1 (10 pts):

A baseball player hits a ball straight up at 100 km per hour. How much time elapses between the moment the ball leaves the bat and the time it hits the ground. Assume the ball is one meter above the ground when it leaves the bat. Ignore air resistance and any rotational motion of the ball.

Problem 2 (10 pts):

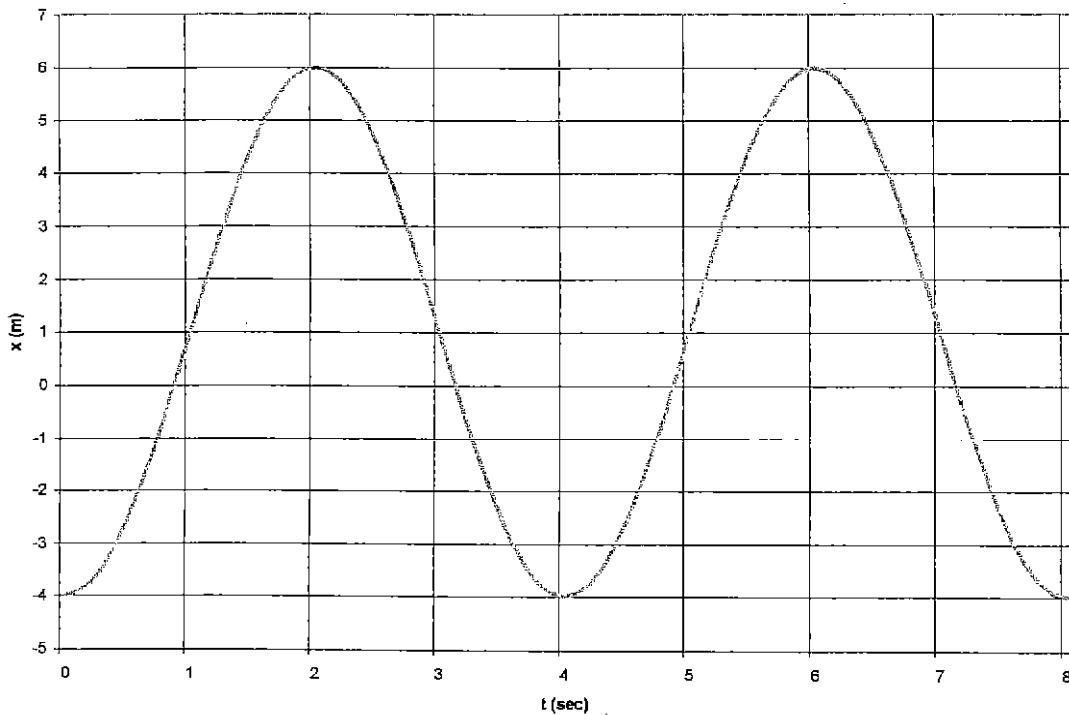
Your mother's car is stuck in the snow. She has to get to work and has asked for your help. You try all the usual tricks such as shoveling around the tires and putting sand around the tires. Nothing seems to work. Then you tie a rope to the car and pull with all the force you can muster (see the left hand figure). No luck. Then you tie the rope to a tree and push as hard as you can in a direction perpendicular to the rope (see the right hand figure). The car moves and is eventually freed. Assume the magnitude of the force that you are able to exert on the rope is identical in both cases and that the rope can stretch slightly. Explain why the latter approach worked. Use diagrams and equations as needed.



Problem 3 (10 pts):

A cork bobbing on the surface of a lake has the vertical displacement as a function of time given by the graph below.

- (a) What is the amplitude for the harmonic motion of the cork (look carefully!)?
- (b) What is the period of the simple harmonic motion of the cork?
- (c) What is the frequency of the water wave passing by the cork?
- (d) What is the wavelength of the water wave passing by the cork (assume the velocity of the wave is 1 m/s)?
- (e) Write a mathematical expression that describes the vertical motion of the cork with time.



Problem 4 (10 pts):

(a) When you lock the brakes in a moving car, the front end of the car moves down while the back end rises. Explain why this is so.

(b) Hydrogen or helium filled dirigibles and hot air balloons are often called "lighter than air" craft. Is this an accurate description? Why or why not.

Problem 5 (10 pts):

A body of mass m is whirled at a constant angular velocity on the end of a string of length R . Calculate the length of string (in terms of R) needed to double the kinetic energy of the body while maintaining the angular velocity.

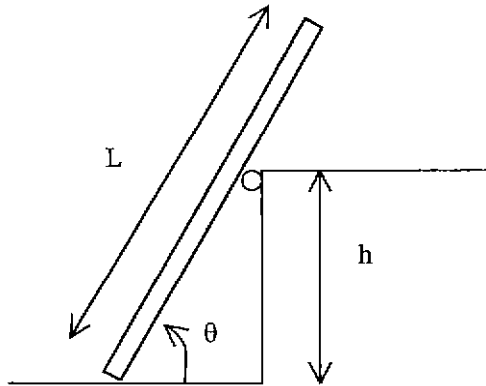
Problem 6 (10 pts):

A rod of an unknown material has a length of 20.05 cm as measured on a steel ruler (steel has a linear coefficient of thermal expansion of 1.2×10^{-5} per degree centigrade). Both the rod and the steel ruler are placed in an oven at 270 degrees centigrade. At the new temperature the rod measures 20.11 cm on the same ruler. What is the linear coefficient of thermal expansion for the unknown material?

Problem 7 (10 pts):

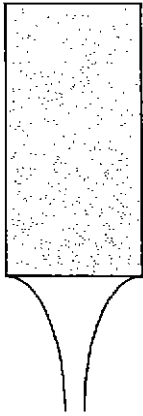
A uniform wooden plank of length $L=6.10$ m and a weight of 445 N, rests on the ground and against a frictionless roller at the top of a wall of height $h=3.05$ m. The plank remains in equilibrium for any value of $\theta \geq 70$ degrees, but slips if $\theta < 70$ degrees.

- (a) Draw the relevant forces on the diagram below.
- (b) Find the coefficient of static friction between the plank and the ground.



Problem 8 (10 pts):

- (a) Courageous physics students pour non-alcoholic beer in a funnel and watch it pour on the floor as they prepare for a physics project. They notice the stream narrows as the beer falls from the funnel. Washing up later, they notice as water emerges from a faucet, the stream narrows as the water falls. Being unrepentant physics geeks, they hypothesize the narrowing is due to the same physical effect in both cases. Explain the cause for the narrowing of the fluid stream in these examples. (The cause is the same in both cases and has nothing to do with the specific nature of the fluid or the state of mind of the observers.)



- (b) Two tuning forks have identical frequencies, but one is stationary and the other is mounted at the rim of a rotating platform. What does a listener hear and why?

Problem 9 (10 pts):

A T-bar tow pulls skiers up a 600-m slope inclined at 15 degrees with respect to the horizontal. (The slope is 600-m in length, not height.) Assume the mass of the average skier is 75 kg. Assume the rope and T-bars are massless.

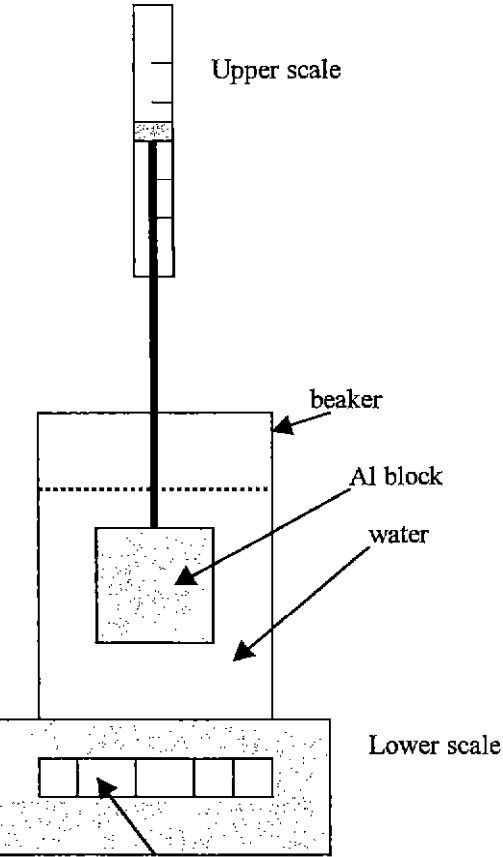
(a) Let the slope be frictionless. How much work is expended by the rope tow pulling one skier up the slope?

(b) Suppose $\mu_k=0.06$ (the slope is no longer frictionless). How much work is expended by the rope tow pulling one skier up the slope?

(c) This rope tow is designed to pull 80 skiers up the slope at 2.5 m/s. Assuming $\mu_k=0.06$, what is the power required for the rope tow motor?

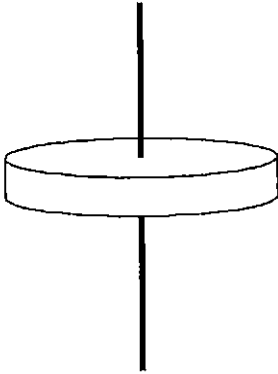
Problem 10 (10 pts):

A beaker of mass 1 kg containing 2 kg of water rests on a scale. A 2-kg block of aluminum (specific gravity 2.7) suspended from a spring scale is submerged in the water as in the figure below. Find the readings on both scales.



Problem 11 (10 pts):

Use integration to determine the moment of inertia of a thin, uniform disk of mass M , radius R and thickness h rotating about an axis perpendicular to the plane of the disk and passing through the center of the disk. **Hint:** The differential volume of an annular ring of width dr is $dv=(2\pi rh)dr$



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It'll be a few days before I'll be able to pull together the final grades in the course. Once I have the final grades, I plan to email you individually with the information that I have for you in my spreadsheet. You'll want to check it for accuracy. This will only happen if you have given me your xxxx.mail.rochester.edu address. You can look on the project listings (on the class website) to see if I have the correct address for you in my spreadsheet.

Have a great summer! Don't bore your parents with too much discussion of interference in the water waves on the lake!