PHYSICS 105S

Homework Assignment #6 **Due at 9am Tuesday, June 12, 2007**

NAME: ____

DISCUSSION SECTION:
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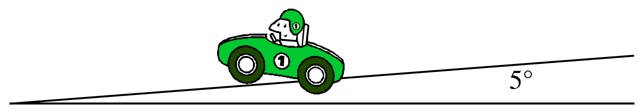
INSTRUCTIONS:

1. Please include appropriate units with all numerical answers.
2. **Please show all steps in your solutions!** If you need more space for calculations, use the back of the page preceding the question. For example, calculations for problem 3 should be done on the back of the page containing question 2. **You must show correct work to receive full credit. Support your answers with brief written explanations and/or arguments based on equations.**
3. **Indicate clearly** which part of your solution is the final answer.
4. Try answering these problems without a calculator.

Angle ( )	**sin( )**	**cos( )**
30°	$\frac{1}{2}$	$\frac{\sqrt{3}}{2}$
45°	$\frac{\sqrt{2}}{2}$	$\frac{\sqrt{2}}{2}$
60°	$\frac{\sqrt{3}}{2}$	$\frac{1}{2}$

Problem 1. Work for car going up hill [25 points]

A 1200 kg car is driven up a 5.0° slope that is 290 m long. Because of the internal mechanisms of the motor, the transmission, and the wheels in contact with the road, the car is propelled forward by a constant force **F** directed along the road. There is also gravity **W** directed downward, a normal force $\mathbf{F_N}$ directed perpendicular to the road, and a constant frictional force $\mathbf{F_f}$ = 524 N directed along the road associated with rolling friction in the tires. Neglect air resistance (which would not be independent of speed).



(a) [2 pts] The force **F** follows the rules for:
[ ] kinetic friction [ ] static friction [ ] abnormal force [ ] antigravity [ ] nuclear fusion

(b) [5 pts] Draw a free body diagram showing all the forces acting on the car.

(c) [3 pts] Calculate the work done on the car by $\mathbf{F_N}$ from the bottom to the top of the hill.

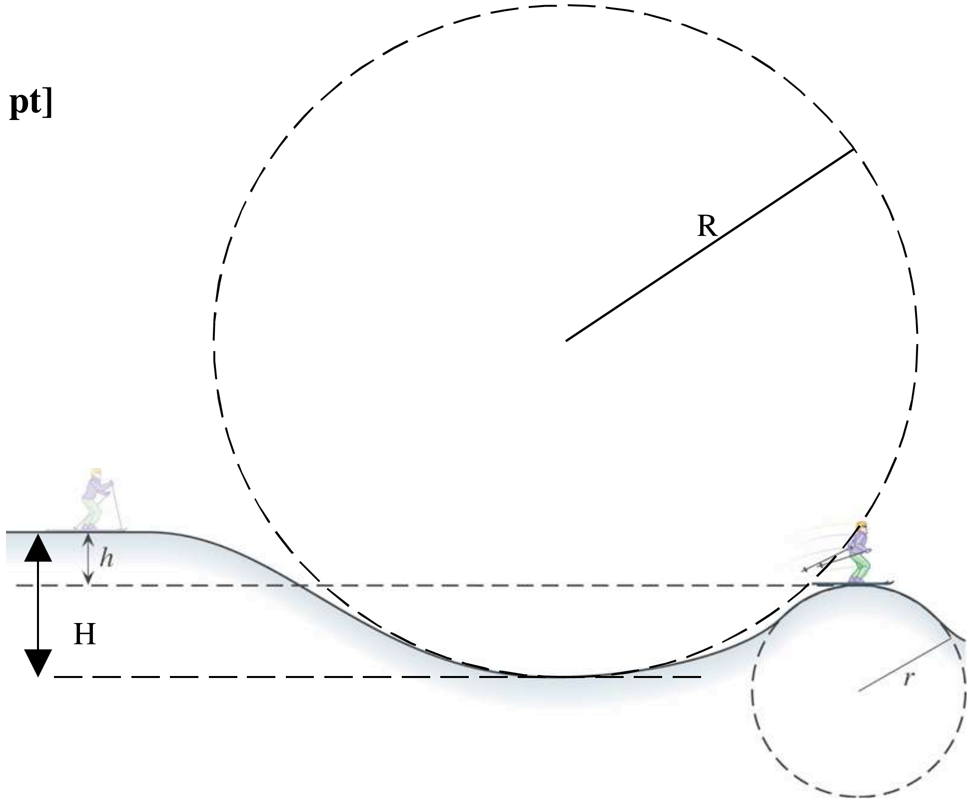
(d) [5 pts] Calculate the work done on the car by **W** from the bottom to the top of the hill.

(e) [5 pts] Calculate the change of gravitational energy of the car from the bottom to the top of the hill.

(e) [5 pts] If the kinetic energy of the car increased by +150 kJ from the bottom to the top of the hill, how much work was done by **F**, and what was the magnitude of **F**?

Problem 2. Skiing on ice [30 pt]

The valley is a distance $\boldsymbol{H}$ **= 6m** below the starting point and has a radius of curvature $\boldsymbol{R}$ **= 20m**. The next hill is only a distance $\boldsymbol{h}$ **= 2m** below the original height, and has a radius of curvature $\boldsymbol{r}$ **= 5m**. The skier of mass $\boldsymbol{m}$ **= 60 kg** pushes off against a rock and starts with $\boldsymbol{v_o}$ **= 3 m/s**. Take $\boldsymbol{g}$ **= 10 m/s²**.



a) [6 pts] If there is no friction, calculate the speed of the skier at the bottom of the valley.

b) [4 pts] If there is no friction, calculate the apparent weight of the skier at the bottom of the valley.

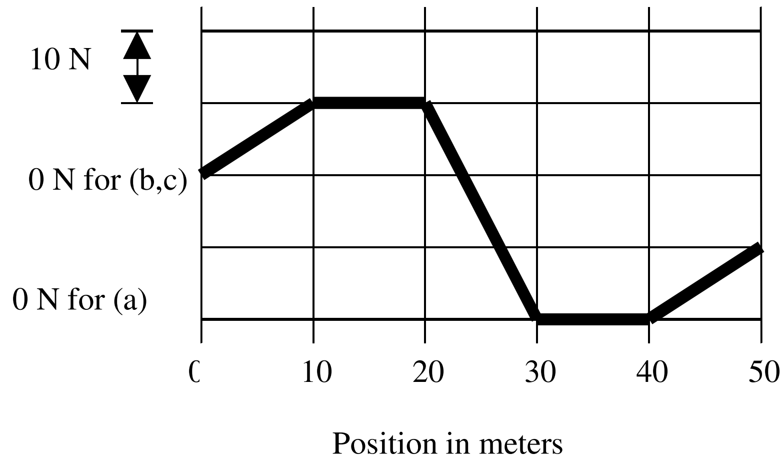
c) [6 pts] If there is no friction, calculate the speed of the skier at the top of the next hill.

d) [4 pts] If there is no friction, calculate the apparent weight of the skier at the top of the next hill.

e) [6 pts] Assume that a snow surface would have a certain amount of friction, such that the skier just comes to rest at the top of the next hill. Calculate the work done by friction.

f) [4 pts] If the total distance traveled is D = 40 m, and the average normal force is something like 0.9 mg, estimate the coefficient of friction of the snow.

Problem 3. Force versus position graphs [20 points]



Remember that the area under a graph of Force vs. Position gives the work done over that interval of position.

Consider three cases, and give the kinetic energy at each position grid line for each case in the table below.

Case (a): [10 pt] Assume that the bottom grid line is zero newtons, so that the force is always positive, and the scale goes from 0 N to 50 N. The particle starts from rest at position 0 meters.

Case (b) and (c): [10 pt total] Assume that the bottom grid line is –20 N so that the scale goes from –20 N to + 20 N.

(b) The particle starts with 500 J of kinetic energy at 0 m, headed in the positive direction.
(c) The particle starts with 100 J of kinetic energy at 0 m, headed in the positive direction.

Case \ @	0 m	10 m	20 m	30 m	40 m	50 m
(a) [2 ea]	0 J					
(b) [1 ea]	500 J					
(c) [1 ea]	100 J					

Problem 4. Power – How fast, etc? [25 points]

MINI Cooper Coupe, 2546 lbs curb weight, maximum power 118 hp, 40 / 32 miles per gallon highway / city

Ferrari 599 GTB Fiorano, 3722 lbs curb weight, 620 hp, 15 / 11 miles per gallon highway / city

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(a) [6 pts] Convert the maximum powers to kW.

(b) [5 pts] The Ferrari has roughly 5 times the maximum power. At high speeds, air resistance is the most important limiting force. The force of air resistance F is proportional to v^2 and therefore the power required to overcome air resistance (F v) is proportional to v^3. Assume that the form factors of the cars are similar, so that they have the same constants of proportionality. Based on this information, estimate how many times faster a Ferrari can go than a MINI.

(c) [5 pts] In the mountains with twisty unbanked turns and cliffs at the edge of the road, relying only on friction, which car would have the larger safe speed on the tight turns? Explain your reasoning.

(c) To establish the EPA miles per gallon ratings, both cars are tested the same way, based on programs of speed appropriate for highway driving and for city driving. Compared to one Ferrari, approximately how many MINI's does it take to put the same amount of CO_2 (a greenhouse gas indicted in global warming) into the atmosphere …

i) [3 pts] driving down Commonwealth Avenue at legal speeds?

ii) [3 pts] driving between Boston and San Francisco at legal speeds?

iii) [4 pts] driving across the desert at top speed? Explain your reasoning.