Sample Problems for Common Exam 3, Physics 105, Fall 2008

1. A car with a mass of 5 T and with good tires can decelerate on a rainy day at about 2.5 m/s² when braking with its wheels locked. If the car is initially traveling at 90 km/h, and then stops after braking, what is the work done on it by the friction force?

\[
\text{Force on the car: normal, gravity, friction} \\
\text{(work by friction)} = W_{\text{net}} = F_{\text{f}} = -\mu_k F_N = -\mu_k mg = ma
\]

\[
\frac{5T}{5000} = \frac{a}{90} = \frac{-1.56 \times 10^6 J}{9.8} = -0.25
\]

2. Using the information in Pr. 1, find the coefficient of kinetic friction between the road and the car during the rain:

\[
\text{Net force} = ma \\
F_{\text{net}} = F_{\text{f}} = -\mu_k F_N = -\mu_k mg = ma
\]

\[
\mu_k = \frac{a}{g} = \frac{-2.5}{9.8} = 0.25
\]

3. A 10-kg lamp is suspended by a string from the ceiling inside an elevator moving down with decreasing speed. If the magnitude of the elevator's acceleration is 2 m/s², what is the work done by the string tension force in slowing the lamp from 10 m/s down to the full stop?

\[
\text{Work done by tension force} = W_T = \int F_T \, dx = \int (T - mg) \, v \, dt
\]

\[
y - y_0 = \frac{1}{2} a \, t^2 \Rightarrow t = \sqrt{\frac{2(y - y_0)}{a}} \Rightarrow d = \frac{1}{2} \cdot 25 \cdot 118 = 118 N
\]

4. A car with its engine off costs along a straight highway, which goes uphill. How far along the highway will the car go before its stops, if its initial speed was 80 km/h, and the slope is 15°?

\[
\text{Work done by friction force} = W_f = \int F_f \, dx = \int -\mu_k F_N \, v \, dt
\]

\[
l = \frac{v^2}{2g \sin \theta} = 95 m
\]

5. A 25-kg block is pulled on a horizontal floor with a force of \( T = 160 \, N \) in the direction \( \theta = 30° \) above the horizontal. The coefficient of kinetic friction between the block and the floor is \( \mu_k = 0.2 \)

\[
\text{Along } y: \left| \frac{T}{\sin \theta} \right| + \frac{f_k}{l} - mg = 0
\]

\[
\Rightarrow \left| \frac{T}{\sin \theta} \right| = mg - \frac{f_k}{l} \sin \theta = 25 \times 9.8 - 165 \times \sin 30° = 165 N
\]

\[
f_k = \mu_k \frac{f_N}{l} = 0.2 \times 165 N = 33 N
\]
a. What is the work done on the block by the kinetic friction force over a distance \( x = 30 \) m?

\[ W_f = - \left[ f_k \right] d = -33 \text{N} \times 30 \text{m} = -990 \text{ J} \]

b. What is the velocity of the block at \( x = 30 \) m if it started from rest?

\[ \text{Normal, gravity } \rightarrow \text{ no work.} \]

\[ W_{net} = W_{f_k} + W_T = K_f - K_i \]

\[ W_T = \frac{1}{2} m v^2 \cos \theta = 160 \text{N} \times 30 \text{m} \times \cos 30^\circ = 4156 \text{ J} \]

\[ W_{net} = 4156 - 990 = 3166 \text{ J} \]

\[ \frac{1}{2} m v^2 = \frac{W_{net} \times x}{2} \]

\[ v = \sqrt{\frac{W_{net} \times x}{2}} = 3166 \times \frac{20}{2} = 16 \text{ m/s} \]

6. A bicyclist is traveling on a horizontal track at a speed of 20.0 m/s as he approaches the bottom of a hill. He decides to coast up the hill and stops upon reaching the top. Determine the vertical heights of the hill.

\[ h_f = \frac{v_f^2}{2g} = \frac{20^2}{2 \times 9.8} = 20 \text{ m} \]

7. A 60 kg skier starts from rest from the top of a 50 m high slope. If the work done by friction is \(-6.0 \times 10^3 \) J, what is the speed of the skier on reaching the bottom of the slope?

\[ W_{nc} = E_{mk} - E_{ci} \]

\[ -6 \times 10^3 = \frac{1}{2} m v_f^2 - mgh_i \]

\[ \frac{1}{2} m v_f^2 = mgh_i - 6 \times 10^3 = 60 \times 9.8 \times 50 - 6 \times 10^3 \]

\[ v_f = \sqrt{\frac{2 \times 3 \times 1000}{20}} = 28 \text{ m/s} \]

8. A 60-kg block is dropped from rest a distance of 1.20 m onto a platform of negligible mass supported by a stiff spring. The block sticks to the platform and the block + platform move another 6 cm before their speed become equal to zero for the first time. What is the value of the spring constant?

Solved in class.