

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/s^2 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?

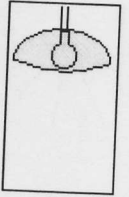
$5 \text{ T} = 5000 \text{ kg}$
 Force on the car: normal, gravity, friction
 (work by friction) = $W_{\text{net}} = K_f - K_i = \frac{1}{2} m v_f^2 - \frac{1}{2} m v_i^2 = -1.56 \times 10^6 \text{ J}$
 $\rightarrow 90^\circ \text{ w.r.t. motion} \rightarrow \text{no work.}$

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

$F_{\text{net}} = m a$
 $F_{\text{net}} = -|f_k| = -\mu_k F_N = -\mu_k m g = m a$
 $\therefore \mu_k = -\frac{a}{g} = -\frac{-2.5}{9.8} = \boxed{0.25}$
 $a = +2 \text{ m/s}^2$

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/s^2 , what is the work done by the string tension force in slowing the lamp from 10 m/s down to the full stop?

Force on the lamp: tension, gravity
 conservative force

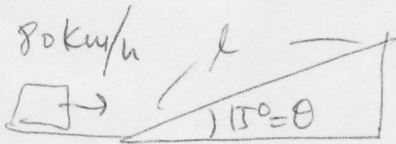


$F_{\text{net}, y} = m a_y$
 $|\vec{T}| - m g = m a_y$
 $|\vec{T}| = m(g + a) = 10 \times (9.8 + 2) = \boxed{118 \text{ N}}$

$W_T = \vec{T} \cdot \vec{d} = -2950 \text{ J}$

$y - y_0 = \frac{v_f^2 - v_i^2}{2a} = -25 \text{ m} \Rightarrow |\vec{d}| = \boxed{25 \text{ m}}$

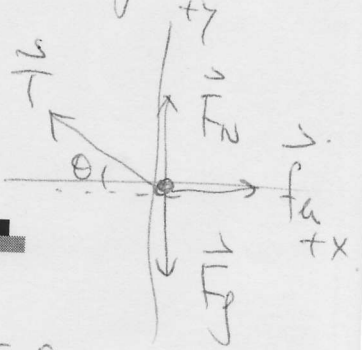
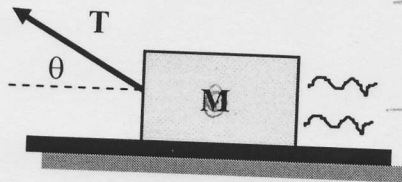
4. A car with its engine off coasts along a straight highway, which goes uphill. How far along the highway will the car go before it stops, if its initial speed was 80 km/h, and the slope is 15° ?



$E_{m,i} = E_{m,f}$

$\frac{1}{2} m v_i^2 = m g h_f = m g l \sin \theta$

$\therefore l = \frac{v^2}{2g \sin \theta} = 95 \text{ m}$



Along y: $|\vec{T}| \sin \theta + |\vec{F}_N| - m g = 0$

$\therefore |\vec{F}_N| = m g - |\vec{T}| \sin \theta = 25 \times 9.8 - 160 \sin 30^\circ = 165 \text{ N}$

$|\vec{f}_a| = \mu_k |\vec{F}_N| = 0.2 \times 165 \text{ N} = 33 \text{ N}$

5. A 25-kg block is pulled on a horizontal floor with a force of $T = 160 \text{ N}$ in the direction $\theta = 30^\circ$ above the horizontal. The coefficient of kinetic friction between the block and the floor is $\mu_k = 0.2$

a. What is the work done on the block by the kinetic friction force over a distance $x = 30$ m?

$$W_f = -|\vec{f}_k| |\vec{d}| = -33\text{N} \times 30\text{m} = -990\text{ J}$$

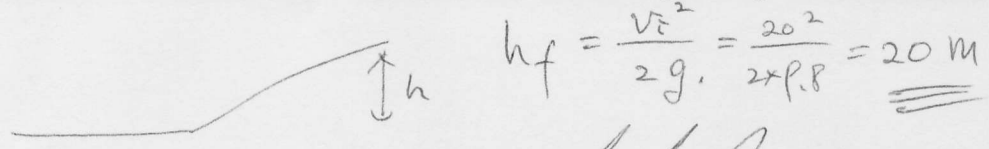
b. What is the velocity of the block at $x = 30$ m if it started from rest?

~~Normal~~ $\vec{F}_N, \vec{F}_g \perp \vec{d} \therefore$ Normal, gravity \rightarrow no work.

\therefore ~~Net~~ $W_{\text{net}} = W_{f_k} + W_T = K_f - K_i \therefore$ work-energy theorem.

$$W_T = |\vec{T}| |\vec{d}| \cos\theta = 160\text{N} \times 30\text{m} \times \cos 30^\circ = 4156\text{J} \therefore W_{\text{net}} = 4156 - 990 = 3166\text{J} = \frac{1}{2}mv_f^2$$

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.

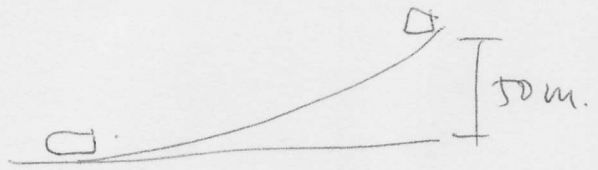


$$E_{m,i} = E_{m,f} \\ \frac{1}{2}mv_i^2 = mgh_f$$

~~$W_{nc} = E_{m,f} - E_{m,i} \\ -6 \times 10^3 = \frac{1}{2}mv_f^2 - mgh_i$~~

$$\therefore v_f = \sqrt{\frac{W_{\text{net}} \times 2}{m}} \\ = \sqrt{\frac{3166 \times 2}{25}} = 16\text{ m/s}$$

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



$$W_{nc} = E_{m,f} - E_{m,i} \\ -6 \times 10^3 = \frac{1}{2}mv_f^2 - mgh_i$$

$$\frac{1}{2}mv_f^2 = mgh_i - 6 \times 10^3 = 60 \times 9.8 \times 50 - 6 \times 10^3 \\ = 23400\text{ J} \\ \therefore v_f = \sqrt{\frac{2 \times 23400}{60}} = 28\text{ m/s}$$

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