PS150.01 **Physics I** **Exam #2**

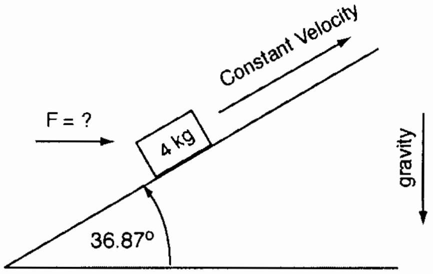
November 8, 2006

Show your work

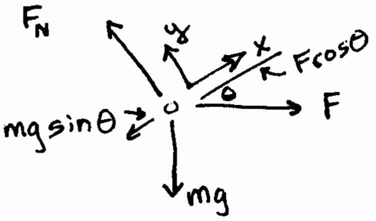
Answer Key
Name

10 points

1. A 4-kg block is moving up a frictionless incline plane at constant velocity as shown in the figure. It does so with the assistance of an external force *F*.



a. Draw a free-body diagram showing all the forces acting on the 4-kg block.



b. Calculate the force required to keep the block moving up the incline plane at constant velocity.

$\Sigma F_x = m a_x = 0$ Newton's 1st Law

$F\cos\theta - mg\sin\theta = 0$

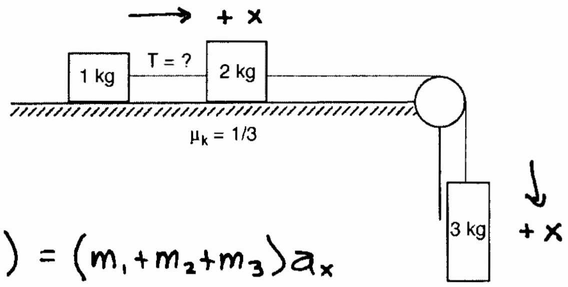
$F = mg\dfrac{\sin\theta}{\cos\theta} = mg\tan\theta$ $\Rightarrow$ $F = 4\,\text{kg}(9.8\,\text{m/s}^2)\,3/4$

$= 29.4$ N

F = 29.4 N

15 points

2. Three masses are connected with massless strings as shown in the figure to the right. The 3-kg mass accelerates the other two masses across a horizontal surface with a kinetic coefficient of friction $\mu_k = 1/3$.



a. Calculate the acceleration of the 3-mass system.

$\Sigma F_x = \text{"}m\text{"}\, a_x \Rightarrow m_3 g - \mu_k(m_1 g + m_2 g) = (m_1+m_2+m_3)a_x$

$a_x = \dfrac{[m_3 - \mu_k(m_1+m_2)]\,g}{m_1+m_2+m_3} = \dfrac{[3-\frac{1}{3}(3)]\,g}{6} = \dfrac{1}{3}g$

$a_x = \frac{1}{3}(9.8\,\text{m/s}^2) = 3.27\,\text{m/s}^2$

a = 3.27 m/s^2

b. Calculate the tension between blocks 1 and 2.

Let "m_1" be the system

$\Sigma F = m_1 a_x \Rightarrow T - \mu_k m_1 g = m_1 a_x$

$T = \mu_k m_1 g + m_1\left(\frac{1}{3}g\right) = m_1 g\left(\mu_k + \frac{1}{3}\right) = \frac{2}{3}m_1 g$

T = 6.53 N

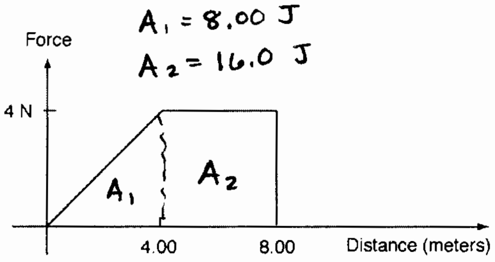
$T = \frac{2}{3}(1\,\text{kg})(9.8\,\text{m/s}^2) = 6.53$ N

10 points

3. A force is applied to a 2.0-kg mass on a horizontal frictionless surface according to the *force diagram* shown in the figure at the right. If the mass is initially at rest at $x = 0.0$ meters,

$A_1 = 8.00\ J$

$A_2 = 16.0\ J$



a. What is its velocity at $x = 4.0$ meters?

$$A_1 = \text{area } 0 \to 4\,m = \frac{1}{2}\, 16\ N\cdot s = 8 \text{ Joules}$$

$$W = \Delta K \qquad 8\,J = \frac{1}{2}mv_f^2 - \frac{1}{2}m\underbrace{v_i^2}_{=0}$$

$$v_f = \sqrt{\frac{2(8\,J)}{2\,kg}} = 2.83\ m/s$$

$v =$ <u>2.83</u> m/s

b. What is its velocity at $x = 8.0$ meters?

$$A_2 = \text{area } 4 \to 8\,m = 16\ N\cdot s$$

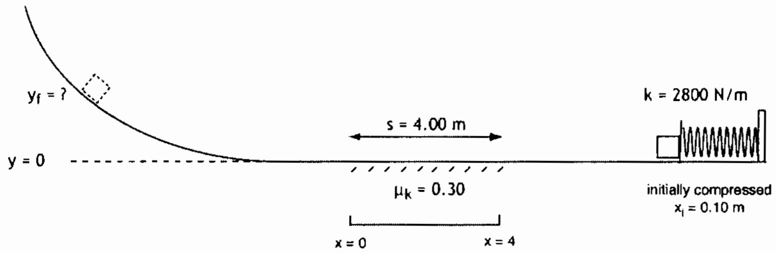
$$W = \Delta K \Rightarrow A_1 + A_2 = \frac{1}{2}mv_f^2 \qquad (8+16)J = \frac{1}{2}(2.0\,kg)v_f^2$$

$$v_f = \sqrt{24\,m^2/s^2} = 4.90\ m/s$$

$v =$ <u>4.90</u> m/s

15 points

4. A 1.0-kg mass is initially at rest in a spring that is compressed a distance of 10.0 cm. The mass is released and moves to the left crossing a friction pad ($\mu_k = 0.30$) 4.0 meters long.



a. How high does the 1.0-kg mass rise up the frictionless ramp on the left-hand side of the figure?

$$W = \Delta K \qquad W_{grav} + W_{sp} + W_{fr} = \underbrace{K_f}_{=0} - \underbrace{K_i}_{=0}$$

$$-mgy_f + \frac{1}{2}kx^2 - \mu_k mgs = \frac{1}{2}mv_f^2 = 0 \Rightarrow mgy_f = \frac{1}{2}kx^2 - \mu_k mgs$$

$$\Rightarrow y_f = \frac{kx^2}{2mg} - \mu_k s = \frac{2800\,N/m\,(0.1\,m)^2}{2(1.0\,kg)(9.8\,m/s^2)} - 0.30(4.0\,m) = 0.229\ m$$

$y_f =$ <u>0.229</u> meters

b. The 1.0-kg mass oscillates back-and-forth across the friction-pad. Where along the friction-pad does it come to rest?

$$W = \Delta K \qquad \underbrace{W_{grav}}_{=0} + W_{sp} + W_{fr} = \underbrace{K_f}_{=0} - \underbrace{K_i}_{=0} = 0$$

$$\frac{1}{2}kx^2 - \mu_k mgd = 0$$

d = distance across the friction pad.

$$d = \frac{kx^2}{2\mu_k mg} = \frac{(2800)(.1\,m)^2}{2(0.3)(1\,kg)(9.8\,m/s^2)} = 4.762$$

$x =$ <u>0.762</u> meters