Name & ID ____

UNIVERSITY OF ALABAMA
Department of Physics and Astronomy

PH 125 / LeClair — Spring 2009

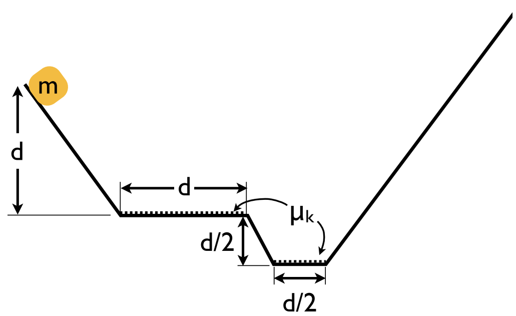
Exam II

Instructions

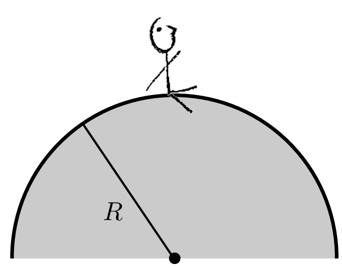
1. **Solve 4 of 6 problems below.**
2. Use the problem solving steps from the template. Attach other sheets as necessary.
3. All problems have equal weight.
4. You must answer all parts of multi-part questions for full credit.
5. Show your work for full credit. Significant partial credit will be given.
6. You are allowed 2 sides of a standard 8.5 x 11 in piece of paper with notes/formulas and a calculator.
7. You have 1h50m.

1. A block of mass m is released from rest at a height $d = 40\,\text{cm}$ and slides down a frictionless ramp and onto a first plateau, which has length d and where the coefficient of kinetic friction is $\mu_k = 0.5$. If the block is still moving, it then slides down a second frictionless ramp through height $d/2$ and onto a lower plateau, which has length $d/2$ and where the coefficient of kinetic friction is again $\mu_k = 0.5$. If the block is still moving, it then slides up a frictionless ramp.

Where is the *final* stopping point of the block? If it is on a plateau, state which one and give the distance L from the *left* edge of that plateau.



2. A boy is initially seated on the top of a hemispherical ice mound of radius R. He begins to slide down the ice, with a negligible initial speed. Approximate the ice as being frictionless. At what height does the boy loose contact with the ice?



3. A uniformly dense rope of length b and mass per unit length λ is coiled on a smooth table. One end is lifted by hand with constant velocity v_o. Find the force of the rope held by the hand when the rope is a distance a above the table $(b > a)$.

Name & ID ____

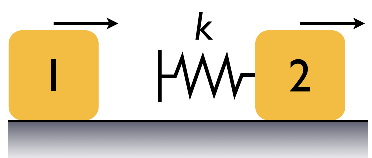
4. Block 1 of mass m_1 is moving rightward at v_1 while block 2 of mass m_2 is moving rightward at $v_2 < v_1$. The surface is frictionless, and a spring of constant k is fixed to block 2. When the blocks collide, the compression of the spring is maximum the instant the blocks have the same velocity.

(a) Show that

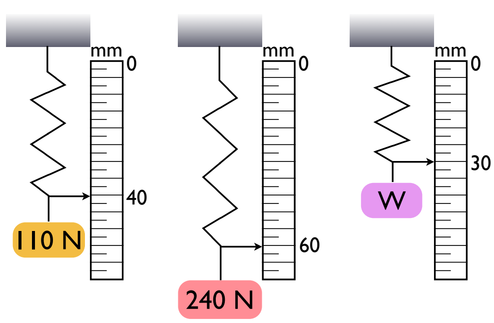
$$\Delta K = K_{1i} + K_{2i} - K_{12} = \frac{1}{2}\mu v_{\text{rel}}^2 \qquad \text{with} \qquad \mu = \frac{m_1 m_2}{m_1 + m_2}$$

where K_{1i} and K_{2i} are the kinetic energies of blocks 1 and 2 before the collision, respectively, K_{12} is the kinetic energy of the system at the moment the spring compression is maximum, and v_{rel} is the relative velocity of the two blocks. The quantity μ is known as the *reduced mass* of the system.

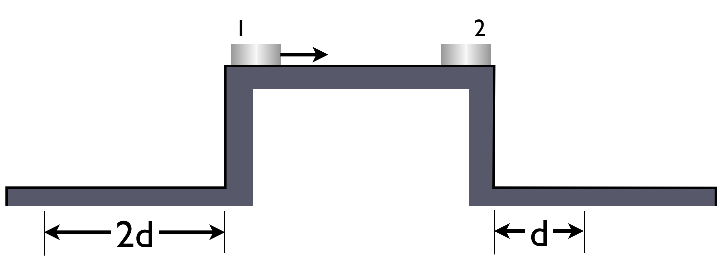
(b) Find the maximum compression of the spring.



5. A spring with a pointer attached is hanging next to a scale marked in millimeters. Three different packages are hung from the spring, in turn, as shown below. **(a)** Which mark on the scale will the pointer indicate when no package is hung from the spring? **(b)** What is the weight W of the third package?



6. In the figure below, puck 1 of mass $m_1 = 0.20\,\text{kg}$ is sent sliding across a frictionless lab bench, to undergo a one-dimensional elastic collision with stationary puck 2. Puck 2 then slides off the bench and lands a distance d from the base of the bench. Puck 1 rebounds from the collision and slides off the opposite edge of the bench, landing a distance $2d$ from the base of the bench. What is the mass of puck 2?



Formula sheet

$$g = 9.81\,\mathrm{m/s^2}$$
$$0 = ax^2 + bx^2 + c \implies x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$
$$1\,\mathrm{N} = 1\,\mathrm{kg \cdot m/s^2}$$
$$1\,\mathrm{J} = 1\,\mathrm{kg\,m^2/s^2} = 1\,\mathrm{N\,m}$$

1-D motion:

$$v(t) = \frac{d}{dt}x(t)$$
$$a(t) = \frac{d}{dt}v(t) = \frac{d^2}{dt^2}x(t)$$
const. acc. $\downarrow$
$$x_f = x_i + v_{xi}t + \frac{1}{2}a_x t^2$$
$$v_f^2 = v_i^2 + 2a_x \Delta x$$
$$v_f = v_i + at$$

Projectile motion:

$$v_x(t) = v_{ix} = |\vec{\mathbf{v}}_i| \cos\theta$$
$$v_y(t) = |\vec{\mathbf{v}}_i| \sin\theta - gt = v_{iy}\sin\theta - gt$$
$$x(t) = x_i + v_{ix}t$$
$$y(t) = y_i + v_{iy}t - \frac{1}{2}gt^2$$
over level ground:
$$\text{max height } = H = \frac{v_i^2 \sin^2\theta_i}{2g}$$
$$\text{Range } = R = \frac{v_i^2 \sin 2\theta_i}{g}$$

Force:

$$\sum \vec{\mathbf{F}} = \vec{\mathbf{F}}_{\text{net}} = m\vec{\mathbf{a}} = \frac{d\vec{\mathbf{p}}}{dt}$$
$$\sum F_i = ma_i \quad \text{by component}$$
$$\vec{\mathbf{F}}_c = \sum F_{\mathrm{r}} = -\frac{mv^2}{r}\,\hat{\mathbf{r}}$$
$$f_k = \mu_k n$$
$$F_s = -kx$$
$$F_g = -mg$$

2-D motion:

$$\vec{\mathbf{r}} = x(t)\,\hat{\boldsymbol{\imath}} + y(t)\,\hat{\boldsymbol{\jmath}}$$
$$x(t) = x_i + v_{ix}t + \frac{1}{2}a_x t^2$$
$$y(t) = y_i + v_{iy}t + \frac{1}{2}a_y t^2$$
$$\vec{\mathbf{a}}(t) = \frac{d^2 s}{dt^2}\,\hat{\mathbf{T}} + \kappa|\vec{\mathbf{v}}|^2\,\hat{\mathbf{N}}$$
$$= \frac{d^2 s}{dt^2}\,\hat{\mathbf{T}} + \frac{|\vec{\mathbf{v}}|^2}{R}\,\hat{\mathbf{N}} \equiv a_N\,\hat{\mathbf{T}} + a_T\,\hat{\mathbf{N}}$$
$$\vec{\mathbf{a}}_c = -\frac{v^2}{r}\,\hat{\mathbf{r}} \quad \text{circ.}$$
$$T = \frac{2\pi r}{v} \quad \text{circ.}$$

Work-Energy:

$$K = \frac{1}{2}mv^2 = \frac{p^2}{2m}$$
$$\Delta K = K_f - K_i = W$$
$$W = \int F(x)\,dx = -\Delta U$$
$$U_g(y) = mgy$$
$$U_s(x) = \frac{1}{2}kx^2$$
$$F = -\frac{dU(x)}{dx}$$
$$K_i + U_i = K_f + U_f + W_{\text{ext}} = K_f + U_f + \int F_{\text{ext}}\,dx$$

Momentum, etc.:

$$x_{\text{com}} = \frac{1}{M_{\text{tot}}}\sum_{i=1}^{n} m_i x_i = \frac{m_1 x_1 + m_2 x_2 + \ldots m_n x_n}{m_1 + m_2 + \ldots m_n}$$
$$v_{\text{com}} = \frac{1}{M_{\text{tot}}}\sum_{i=1}^{n} m_i v_i = \frac{m_1 v_1 + m_2 v_2 + \ldots m_n v_n}{m_1 + m_2 + \ldots m_n}$$
$$F_{\text{net}} = M_{\text{tot}} a_{\text{com}} = \frac{dp}{dt}$$
$$p_{\text{tot}} = M_{\text{tot}} v_{\text{com}}$$
$$\Delta p = p_f - p_i = J = \int_{t_i}^{t_f} F(t)\,dt = F_{\text{avg}}\Delta t$$
$$\Delta p = 0 \quad \text{closed}$$
$$\text{elastic coll:} \begin{cases} v_{1f} = 2v_{\text{com}} - v_{1i} \\ v_{2f} = 2v_{\text{com}} - v_{2i} \end{cases}$$

Power	Prefix	Abbreviation
10^{-12}	pico	p
10^{-9}	nano	n
10^{-6}	micro	µ
10^{-3}	milli	m
10^{-2}	centi	c
10^{3}	kilo	k
10^{6}	mega	M
10^{9}	giga	G
10^{12}	tera	T