Roller Coasters: Theory, Design, and Properties
Short Term 2005
Basic Physics Homework: Forces and Energy

1. Is $|\langle 3, 2, 1\rangle|$ a vector or scalar?

2. Is $\vec{r} \cdot \vec{l}$ a vector or scalar?

3. Is $5(\langle 2, 1\rangle \cdot \hat{i})$ a vector or scalar?

4. Assume there are two forces on a particle. One is gravity ($\vec{g} = \langle 0, -mg\rangle$), and the other is unknown. We do know that the particle has an acceleration vector $\langle 5, 10\rangle$. Find the unknown force.

5. What is the kinetic energy of a 5 kg block sliding on a frictionless surface at 8 m/s?

6. Find the change in potential energy of a 4 kg block that is dropped 10 meters.

7. A ring of mass m rolls down a ramp that makes an angle of 30° with the horizontal. The ring starts at rest, and we will consider it after it has traveled 8 meters.

   a) What is the displacement in the y-direction?
   b) How much potential energy is converted to kinetic energy? (That is, what is the change in potential energy?)
   c) The moment of inertia I is mr^2, and the angular speed ω is related to the translational speed by the equation $r\omega = v$. What is the (translational) speed v?
   d) Find its (translational) speed if instead it is a solid disk ($I = \frac{1}{2}mr^2$).
   e) Now assume the object is a block that slides down with neglibile friction. What speed does it end with?

8. We can describe the points on a loop by the following position vector:

$$\langle \sin s + \frac{s}{3}, 1 - \cos s \rangle$$

Once again, s will vary with position along the loop.

a) The top of the loop is at the point where $s = \pi$. Determine the amount of potential energy a 10 kg mass would have at this point.(As usual, let $h = 0$ when $y = 0$.)
b) In order for a particle to make it around the loop, it must start with enough kinetic energy so that it will still have some speed at the top of the loop. Find the critical speed it must have to make it around the loop.

Looking ahead to tomorrow: Plot the points when $s = 0$, $s = \pi/2$, $s = \pi$, $s = 3\pi/2$, $s = 2\pi$, and "connect the dots" to see the loop.