

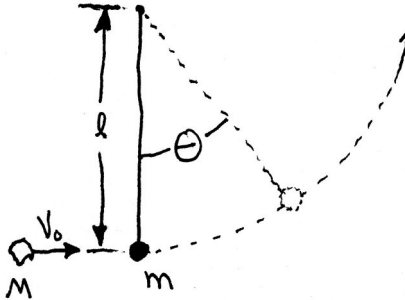
# Survey of Physics (PHYS 100): Exam II EXAMPLE Fall 2007 v1.0

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- Please do use your calculator and your lab notebook, but not other resources.
- Useful relations are collected at the end.
- Please ask questions if you find the statement of the problem unclear.

## Problems:

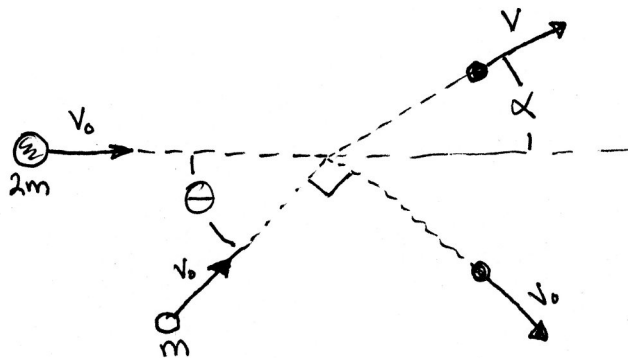
- (1) A small ball of mass  $m$  hangs vertically at the end of a light string. The string has length  $\ell$ . A clay ball with mass  $M$  and speed  $v_o$  collides and sticks to the ball.
- What is the speed of the ball at an angle  $\theta$ ?
  - What initial speed  $v_o$  must the clay ball have to ensure that the ball reaches the top of the circular path without the string becoming slack? Explain your reasoning.



- (2) A spring-powered toy car of mass  $m$  sits on a track with a loop of radius  $R$ . The spring in the car has a constant  $k$ . Find the minimum deflection  $D$  that you have to impart to the spring so that the car safely navigates the loop. Assume there is sufficient friction between the cars wheels and the track and that, otherwise, friction is negligible.

(3) Two objects initially moving at the same speed, 3 m/s, collide at an angle of  $\theta = 30^\circ$ . One object is twice as massive as the other. The lightest mass is deflected by  $\pi/2$ . But its speed is unchanged.

- What is the deflection angle,  $\alpha$ , of the  $2m$  mass?
- What is its speed?
- Is the collision elastic?



- (4) An ice skater performs a pirouette (a fast spin) by pulling in his outstretched arms close to his body.
- (a) What happens to his angular momentum about the axis of rotation?
  - (b) What happens to his rotational kinetic energy about the axis of rotation?
  - (c) What happens to his moment of inertia about the axis of rotation?

- (5) A rotating flywheel can be used to store energy. If are designing a flywheel to store  $1.00 \times 10^6$  J of energy when rotating at 400 rad/s, what is the moment of inertial of the wheel in kg m<sup>2</sup>?

**Possibly useful relations**

$$g = 9.80 \text{ m/s}^2, \quad 1 \text{ ft} = 0.3048 \text{ m}, \quad 1 \text{ year} = 3.156 \times 10^7 \text{ s}$$

$$M_{\text{earth}} = 5.98 \times 10^{24} \text{ kg}$$

$$\mathbf{F} = -\frac{Gm_1m_2}{r^2}\hat{\mathbf{r}} \text{ with } G = 6.67 \times 10^{-11} \text{ Nm}^2\text{kg}^{-2}$$

Translational kinetic energy:

$$K = \frac{1}{2}mv^2$$

Elastic potential energy

$$U_s = \frac{1}{2}kx^2$$

Gravitational potential energy

$$U_g = mgh$$

Conservation of momentum for total momentum  $\mathbf{P}$ ,

$$\mathbf{P}_i = \mathbf{P}_f$$

$$|\mathbf{F}_f| \leq \mu|\mathbf{N}|$$

Rotation:

$$\Delta s = r\Delta\theta, \quad v = r\omega, \quad a_t = r\alpha$$

$$a_r = \frac{v^2}{r}$$

$$\tau = rF_{\text{perp}}$$

$$\mathbf{L} = I\vec{\omega}$$

$$\vec{\tau} = I\vec{\alpha}, \quad \vec{\tau} = \frac{\Delta\mathbf{L}}{\Delta t}$$

For a single mass

$$I = mr^2$$

Rotational kinetic energy:

$$K = \frac{1}{2}I\omega^2$$

Conservation of angular momentum for total momentum  $\mathbf{L}$ ,

$$\mathbf{L}_i = \mathbf{L}_f$$