Announcements

1. Reading – for today: Chapter 8 (Potential energy)

   -- for Monday: Chapter 9 (Momentum)

2. Feedback on this course

3. "Proofs"

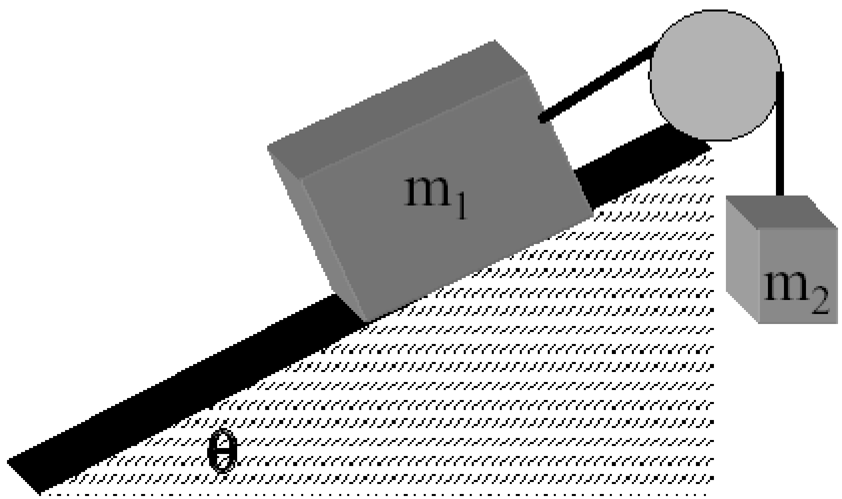
   Will be assigned from time to time; part of HW grade

4. First exam results ~80% average

   Please come to see me if you have question on how to work any of the problems.

   Offer up to 10 extra credit points for turning in reworked exam on Monday 9/30/02.

2.



The figure on the left shows two motionless masses connected by a massless rope which is supported by a massless and frictionless pulley. Mass m_1=5 kg is supported by a surface which has an unknown static friction coefficient μ_s and which is inclined relative to the horizontal direction at an angle of $\theta = 25^o$. The mass m_2=2 kg.

(a) What is the tension in the rope?

(b) What is the static friction force acting on m_1?

(c) What can you say about the static friction coefficient μ_s from the given information?

Peer instruction question

4. An outfielder throws a baseball having a mass of $m = 0.2$ kg with an initial speed of $v_i = 38$ m/s, an initial angle of $\theta_i = 33^o$ relative to the horizontal, and an initial height of $y_i = 1$ m above the ground. For solving this problem, assume that the baseball field is exactly level and that the effects of air friction are negligible.

At what point of the trajectory does the ball have the *least* kinetic energy?

(a) At the beginning? (b) At the top? (c) Just before it hits the ground?

At what point of the trajectory does the ball have the *greatest* kinetic energy?

(a) At the beginning? (b) At the top? (c) Just before it hits the ground?

Energy forms

1. Work: $W = \int_{\mathbf{r}_i}^{\mathbf{r}_f} \mathbf{F} \cdot d\mathbf{r}$

2. Kinetic energy: $K = \frac{1}{2} m v^2$

3. Work-kinetic energy theorem: $W_{total}^{i \to f} = \frac{1}{2} m v_f^2 - \frac{1}{2} m v_i^2$

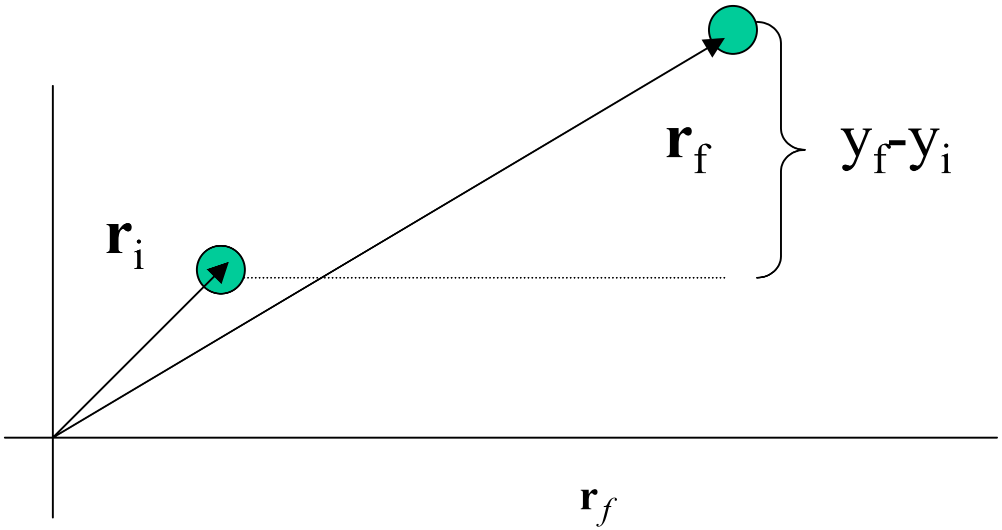
4. Different kinds of contribution to total work:

   a. Conservative (reversible) -- gravity, Hooke's law

   b. Dissipative (irreversible) -- friction

Conservative forces – reversible work

Consider the work done by gravity F_g = -mg **j**



$$W_{i\to f} = \int_{\mathbf{r}_i}^{\mathbf{r}_f} \mathbf{F} \cdot d\mathbf{r} = -mg(y_f - y_i)$$

Note that the work of gravity is: $\begin{cases} > 0 \text{ if } & y_f < y_i \\ < 0 \text{ if } & y_f > y_i \end{cases}$

Conservative forces – reversible work

Define potential energy: $$U(\mathbf{r}) = -\int_{\mathbf{r}_{ref}}^{\mathbf{r}} \mathbf{F} \cdot d\mathbf{r}' = -W(\mathbf{r}_{ref} \to \mathbf{r})$$

Consider the work done by gravity: $F_g = -mg\,\mathbf{j}$

$$W_{i\to f} = \int_{\mathbf{r}_i}^{\mathbf{r}_f} \mathbf{F} \cdot d\mathbf{r}' = -mg(y_f - y_i) = U(y_i) - U(y_f)$$

➔ $U_{gravity}(y) = mgy$ (assuming $y_{ref} = 0$)

Note: Depends only on position (y) (not on path)

$$\mathbf{F} = -\nabla U(y) = -mg\mathbf{j}$$

Using gravitational potential energy in Work-Kinetic energy theorem

$$W_{total}^{i\to f} = \tfrac{1}{2}mv_f^2 - \tfrac{1}{2}mv_i^2$$

Suppose that the total work is done by conservative forces:

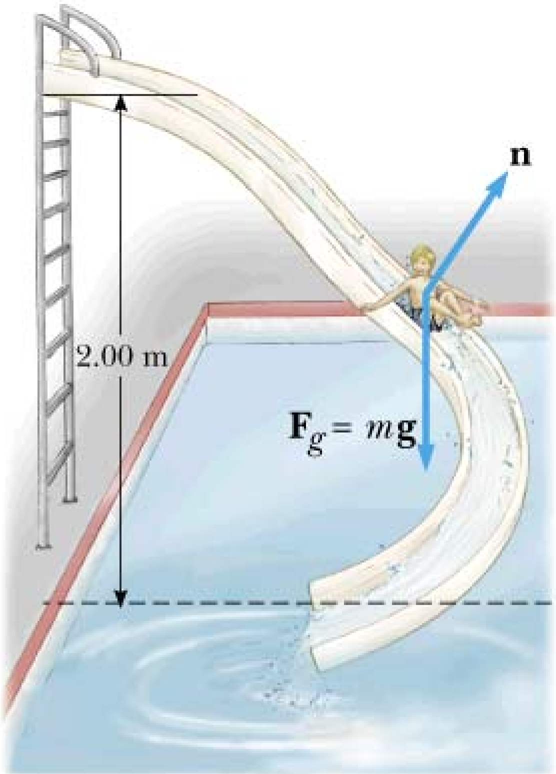
$$W_{total}^{i\to f} = U(\mathbf{r}_i) - U(\mathbf{r}_f) = \tfrac{1}{2}mv_f^2 - \tfrac{1}{2}mv_i^2$$

$$\tfrac{1}{2}mv_f^2 + U(\mathbf{r}_f) = \tfrac{1}{2}mv_i^2 + U(\mathbf{r}_i) \equiv \text{ total mechanical energy}$$

More generally:

$$W_{total}^{i\to f} = W_{conservative}^{i\to f} + W_{dissipative}^{i\to f} = U(\mathbf{r}_i) - U(\mathbf{r}_f) + W_{dissipative}^{i\to f}$$

$$\tfrac{1}{2}mv_f^2 + U(\mathbf{r}_f) = \tfrac{1}{2}mv_i^2 + U(\mathbf{r}_i) + W_{dissipative}^{i\to f}$$



A child of mass m=20kg starts from rest at the top of a 2m slide and has a speed of v_f=3m/s at the end of the ride. How much friction energy does the child generate?

$$\tfrac{1}{2} m v_f^2 + U(\mathbf{r}_f) = \tfrac{1}{2} m v_i^2 + U(\mathbf{r}_i) + W_{dissipative}^{i\to f}$$

$$\tfrac{1}{2} m v_f^2 + 0 \quad = \quad 0 \quad + \ mgh + W_{friction}$$

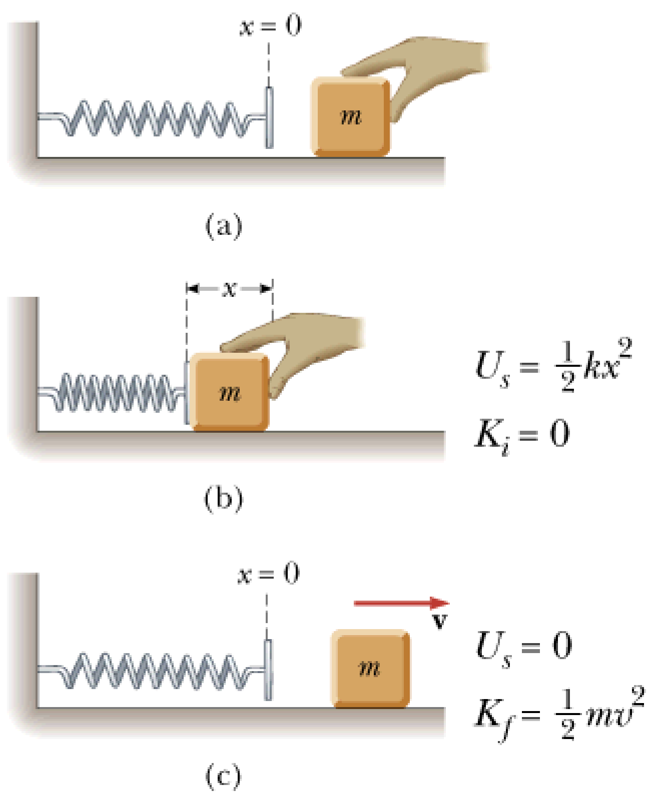
$$\tfrac{1}{2}(20\text{kg})(3\text{m/s})^2 = (20\text{kg})(9.8\text{m/s}^2)(2\text{m}) + W_{friction}$$

$$W_{friction} = -302 \text{ J}$$

Spring force: $F_{spring} = -k(x-x_0)$

$$U_{spring}(x) = -\int_{x_0}^{x} (-k(x'-x_0)dx' = {}^1\!/_2\, k(x-x_0)^2$$

Serway, Physics for Scientists and Engineers, 5/e
Figure 8.2



$$ {}^1\!/_2\, mv_f^2 + U(\mathbf{r}_f) = {}^1\!/_2\, mv_i^2 + U(\mathbf{r}_i) + W_{dissipative}^{i\to f}$$

$$½mv_f^2+0=0+½k(x_i-x_0)^2+0$$

$$v_f = \sqrt{\frac{k}{m}}\,|\,x_i - x_0\,|$$

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