Announcements

1. First hour test on Wednesday, Sept. 25th
   a. May bring one equation sheet (8.5x11”).
   b. Should bring HW notebooks for me to check.
   c. Extra review sessions?
2. Physics Colloquium tomorrow (4 PM Olin 101)– “Analysis of ballast stones from the *Queen Anne's Revenge* by Mössbauer spectroscopy”
3. Complete reading Chapter 7.
4. Scholarships

Scholarship Opportunities for undergraduate students

- **Wake Forest University Research Fellowships**

(for mentored research projects; available to all WFU students with at least sophomore standing and 3.0 GPA)

- **Barry M. Goldwater Scholarships**

(for tuition and expenses support, available to sophomores or juniors planning careers in mathematics, the natural sciences, or engineering -- **Internal deadline: Nov. 8, 2002**)

- **Churchill Scholarships**

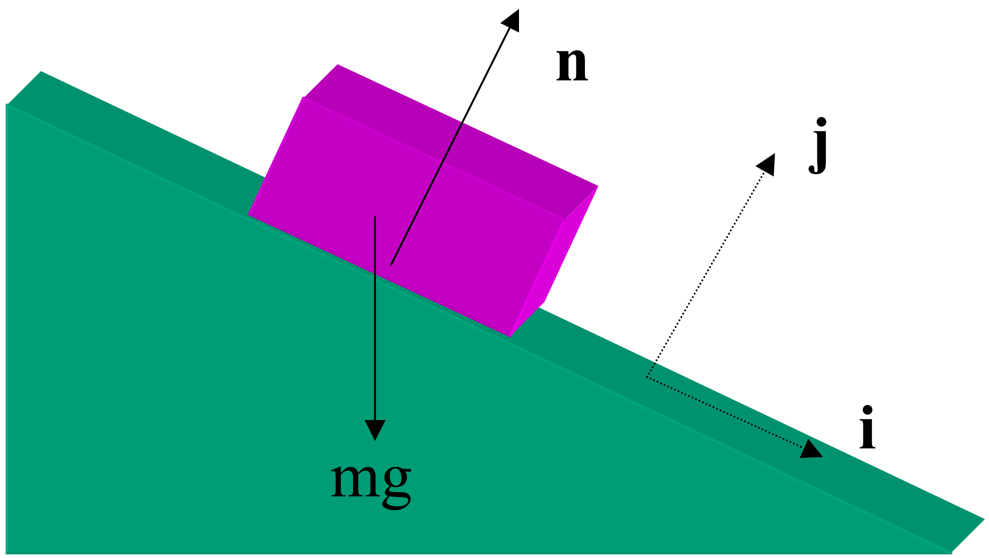
(for one year of graduate study in engineering, mathematics, and the physical and natural sciences at Churchill College, Cambridge University, available to graduating seniors -- **Internal deadline: Nov. 1, 2002; Final deadline: Nov. 15, 2002**)

http://www.wfu.edu/~natalie/scholarships/

Review: Analyzing Newton's laws

$$\mathbf{F} = m\,\mathbf{a} \;\Rightarrow\; F_x\mathbf{i} + F_y\mathbf{j} = ma_x\mathbf{i} + ma_y\mathbf{j}$$

$$\Rightarrow \begin{cases} F_x = ma_x \\ F_y = ma_y \end{cases}$$

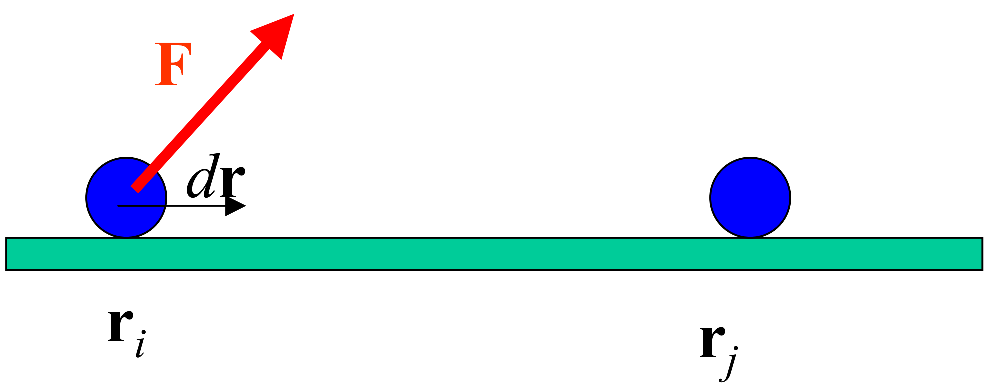


Force ➔ effects acceleration

A related quantity is **Work**

$$W_{i\to f} = \int_{\mathbf{r}_i}^{\mathbf{r}_f} \mathbf{F} \cdot d\mathbf{r}$$

$$\mathbf{A \cdot B} = AB \cos\theta$$



Units of work:

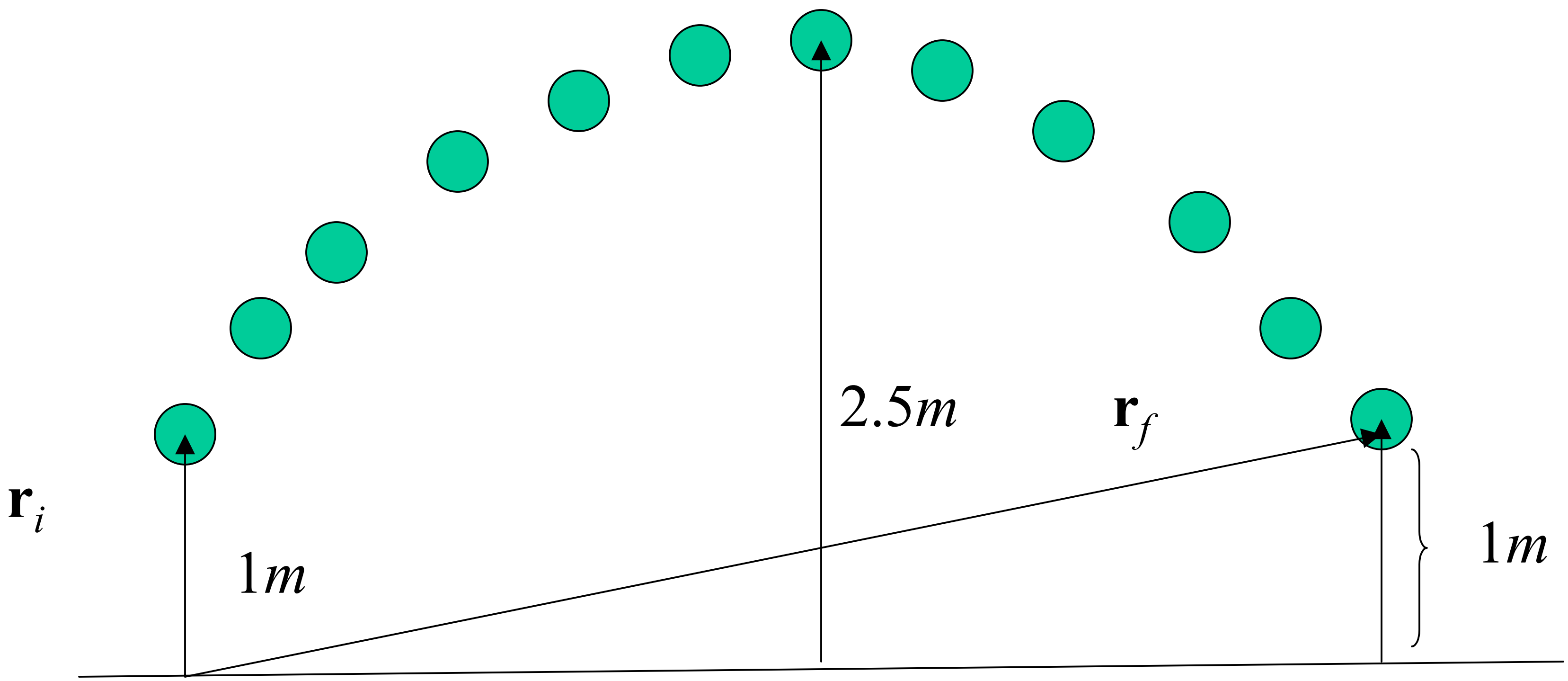
work = force • displacement = (N • m) = (joule)

- Only the component of force in the direction of the displacement contributes to work.
- Work is a *scalar* quantity.
- If the force is not constant, the integral form must be used.
- Work can be defined for a specific force or for a combination of forces

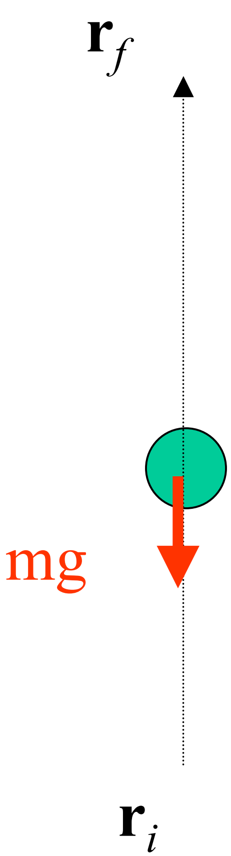
$$W_1 = \int_{\mathbf{r}_i}^{\mathbf{r}_f} \mathbf{F}_1 \cdot d\mathbf{r} \qquad W_2 = \int_{\mathbf{r}_i}^{\mathbf{r}_f} \mathbf{F}_2 \cdot d\mathbf{r} \qquad W_{1+2} = \int_{\mathbf{r}_i}^{\mathbf{r}_f} (\mathbf{F}_1 + \mathbf{F}_2) \cdot d\mathbf{r} = W_1 + W_2$$

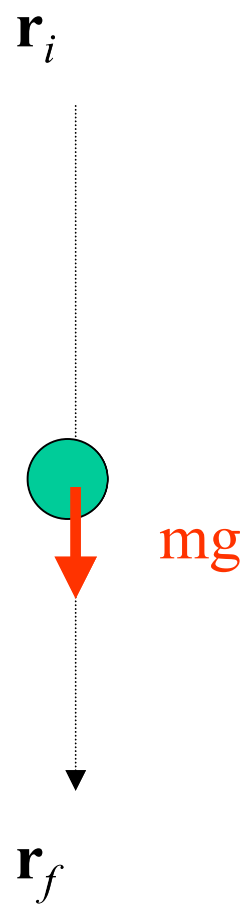
Peer instruction question

A ball which has a weight of 5 N follows the trajectory shown. What is the work done by gravity from the initial $\mathbf{r}_i$ to final displacement $\mathbf{r}_f$?



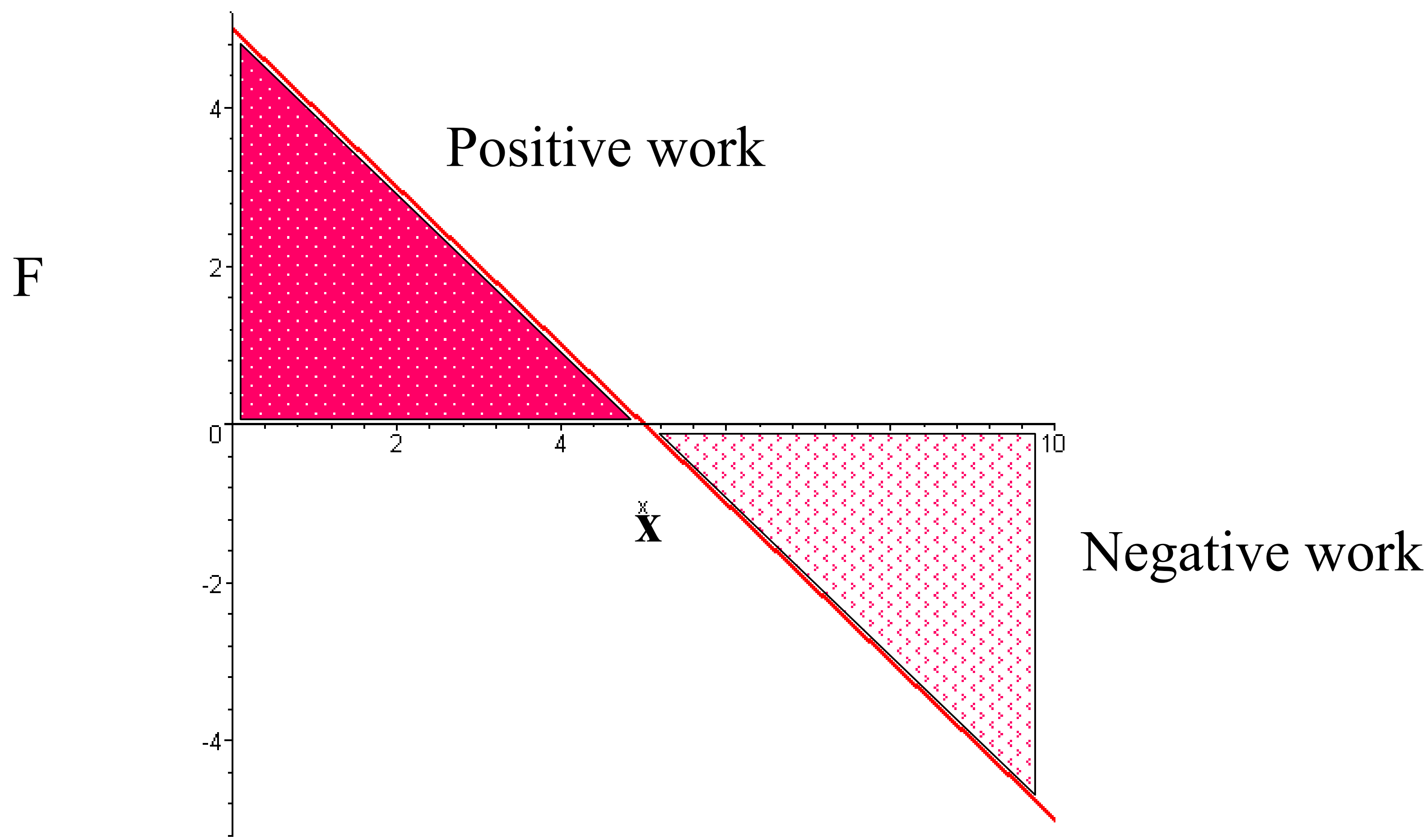
(a) 0 J (b) 5 J (c) 7.5 J (d) 15 J





$W=-mg(rf-r_i)<0$

$W=-mg(r_f-r_i)>0$



F
Positive work
Negative work
x
0
2
4
10
-2
-4

More examples:

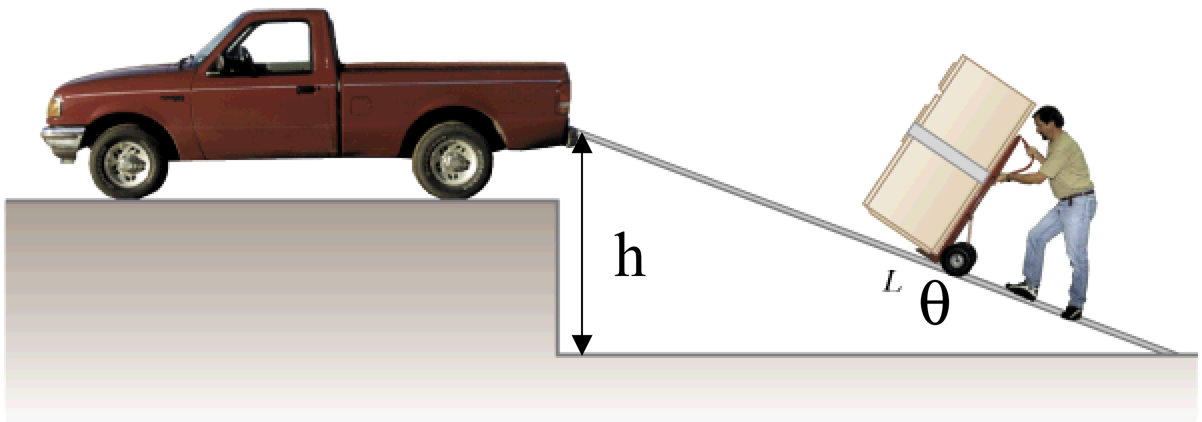
Suppose a rope lifts a weight of 1000N by 0.5m at a constant upward velocity of 2m/s. How much work is done by the rope?

$W=500$ J

Suppose a rope lifts a weight of 1000N by 0.5m at a constant upward acceleration of $2m/s^2$. How much work is done by the rope?

$W=602$ J

Serway, Physics for Scientists and Engineers, 5/e
Figure 7.17



How much work must the man exert on the refrigerator (weight w) to bring it to the truck at constant velocity?

$$W = w \sin\theta L = wh$$

Why is work a useful concept?

Consider Newton’s second law:

$$\mathbf{F}_{\text{total}} = \text{m}\,\mathbf{a} \quad \Rightarrow \quad \mathbf{F}_{\text{total}} \bullet \text{d}\mathbf{r} = \text{m}\,\mathbf{a} \bullet \text{d}\mathbf{r}$$

$$\int_{\mathbf{r}_i}^{\mathbf{r}_f} \mathbf{F}_{total}\cdot d\mathbf{r} = \int_{\mathbf{r}_i}^{\mathbf{r}_f} m\mathbf{a}\cdot d\mathbf{r} = \int_{\mathbf{r}_i}^{\mathbf{r}_f} m\frac{d\mathbf{v}}{dt}\cdot d\mathbf{r} = \int_{\mathbf{r}_i}^{\mathbf{r}_f} m\frac{d\mathbf{v}}{dt}\cdot\frac{d\mathbf{r}}{dt}dt = \int_{\mathbf{r}_i}^{\mathbf{r}_f} m\frac{d\mathbf{v}}{dt}\cdot\mathbf{v}dt$$

$$\text{W}_{\text{total}} = \underbrace{\tfrac{1}{2}\,\text{m}\,\text{v}_{\text{f}}^2 - \tfrac{1}{2}\,\text{m}\,\text{v}_{\text{i}}^2}_{\text{Kinetic energy (joules)}}$$