Reminders:

Exam preparation advice

a. Prepare equation sheet
   - Basic equations used to solve problems
   - Should be able to derive equations from fundamental laws and definitions
b. Review Homework problems
c. Work as many problems as you can from old exams and other sources
d. Get all of your questions answered
e. Don't panic! (Most of you will be able to drop your lowest exam.)

Introduction of the notion of Kinetic energy

Derivation:

Consider Newton's second law:

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

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

$$\int_{t_i}^{t_f} m \frac{d\mathbf{v}}{dt} \cdot \mathbf{v} dt = \int_{\mathbf{v}_i}^{\mathbf{v}_f} m d\mathbf{v} \cdot \mathbf{v} = \int_{i}^{f} d\left(\frac{1}{2} m \mathbf{v} \cdot \mathbf{v}\right) = \frac{1}{2} m v_f^2 - \frac{1}{2} m v_i^2$$

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

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

$$\text{units: } (\text{kg})\,(\text{m/s})^2 = \underbrace{(\text{kg m/s}^2)}_{\text{N}}\ \underbrace{\text{m}}_{\text{m}} = \text{joules}$$

Work – kinetic energy relation:

$$\boxed{W_{total} = K_f - K_i}$$

On line quiz

Suppose you hit a golf ball having a mass of 0.4 kg with an initial velocity of v_i= 150 m/s and an initial angle of 45 deg. Assume that the ball makes a perfectly parabolic trajectory and lands at the same vertical height as it started.

1. What is the initial kinetic energy of the ball?

(a) -2250 J (b) 2250 J (c) -4500 J (d) 4500 J

2. What is the final kinetic energy of the ball just before it reaches the ground?

(a) -2250 J (b) 2250 J (c) -4500 J (d) 4500 J

3. What is the kinetic energy of the ball at the highest point of the trajectory?

(a) -2250 J (b) 2250 J (c) -4500 J (d) 4500 J

Peer instruction questions

Suppose you have a 0.3 kg ball which you want to throw or drop. Under which of these conditions will the ball have the *greatest* kinetic energy just before it hits the ground? (Neglect any effects of air friction.)

(a) You throw it with a velocity of 9m/s at angle of 45^{o} above the horizontal at a distance of 1m above the ground.

(b) You throw it with a velocity of 9m/s at angle of 45^{o} below the horizontal at a distance of 1m above the ground.

(c) You drop it from rest at a distance of 1m above the ground.

(d) You drop it from rest at a distance of 2m above the ground

Examples of the work—kinetic energy relation:

Suppose F_{total} = constant= F_0

$$W_{total} = K_f - K_i$$

$$\Rightarrow F_0(x_f - x_i) = \tfrac{1}{2} mv_f^2 - \tfrac{1}{2} mv_i^2$$

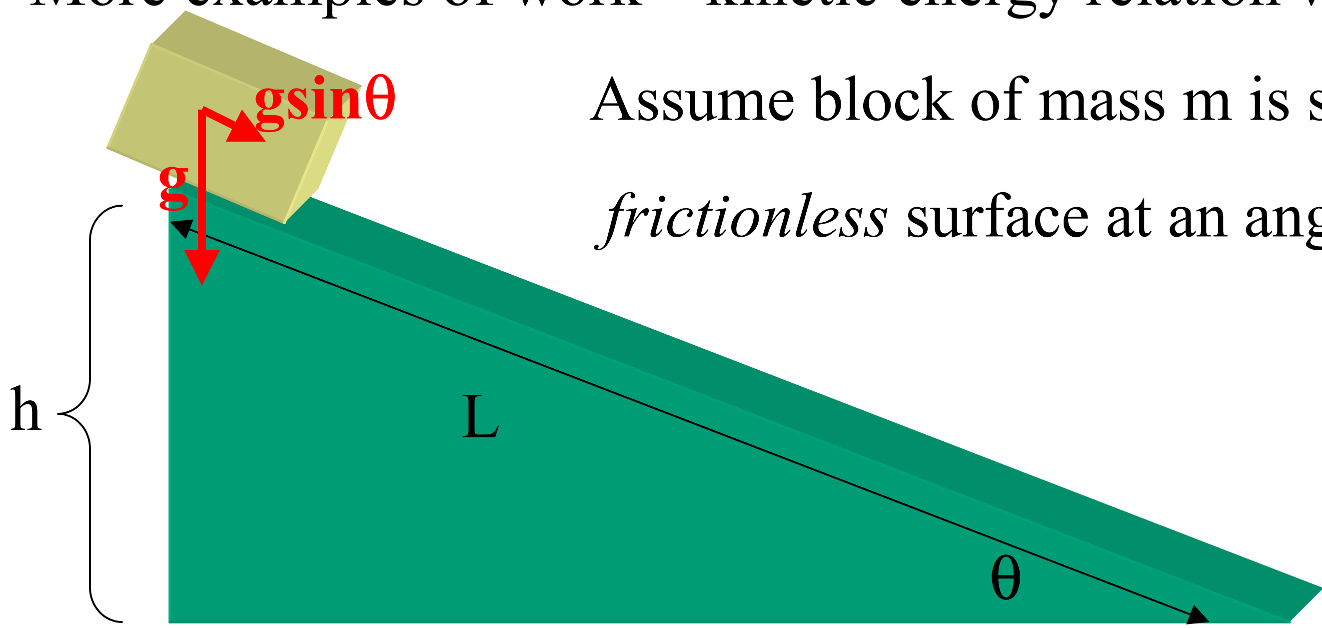
In this case, we also know that $F_0 = ma_0$ so that,

$$F_0(x_f - x_i) = ma_0\,(x_f - x_i) = \tfrac{1}{2} mv_f^2 - \tfrac{1}{2} mv_i^2$$

$$\Rightarrow v_f^2 = v_i^2 + 2a_0\,(x_f - x_i)$$

More examples of work—kinetic energy relation without friction:

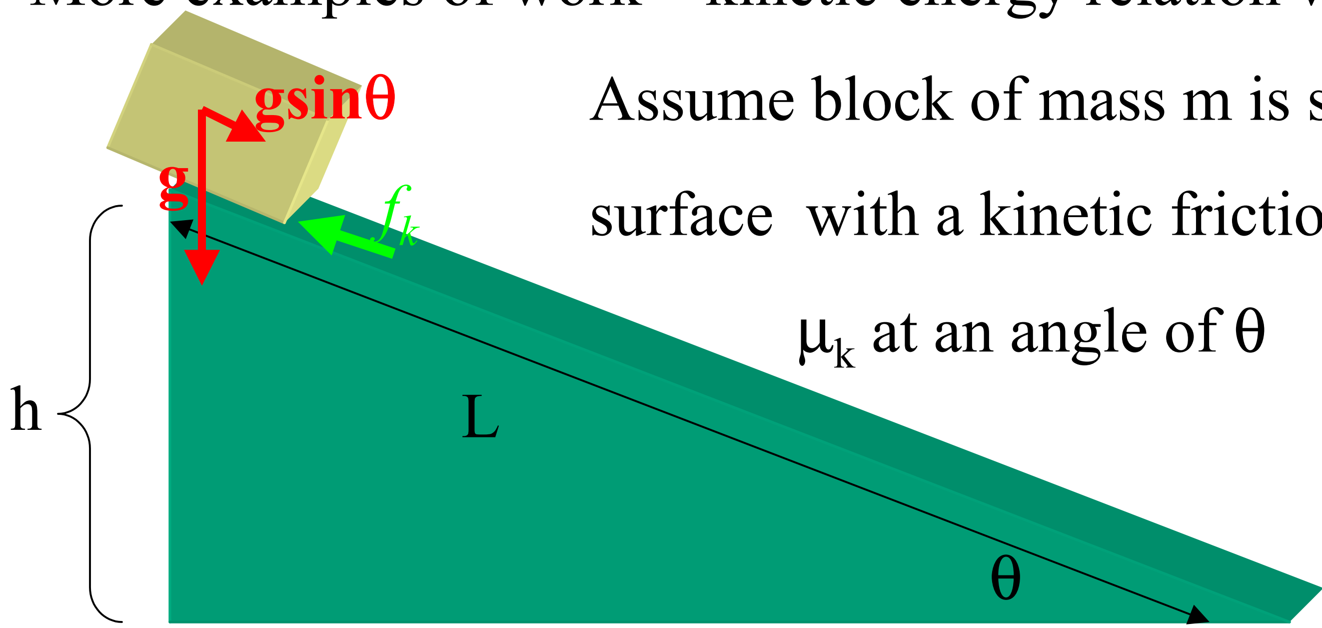
Assume block of mass m is sliding down a *frictionless* surface at an angle of θ



kinematic analysis: $v_f^2 = v_i^2 + 2a_0 (x_f - x_i) = 0 + 2(g \sin\theta)L = 2gh$

energy analysis: $W_{total} = mgh = \frac{1}{2} m v_f^2$

More examples of work—kinetic energy relation with friction:



Assume block of mass m is sliding down a surface with a kinetic friction coefficient of μ_k at an angle of θ

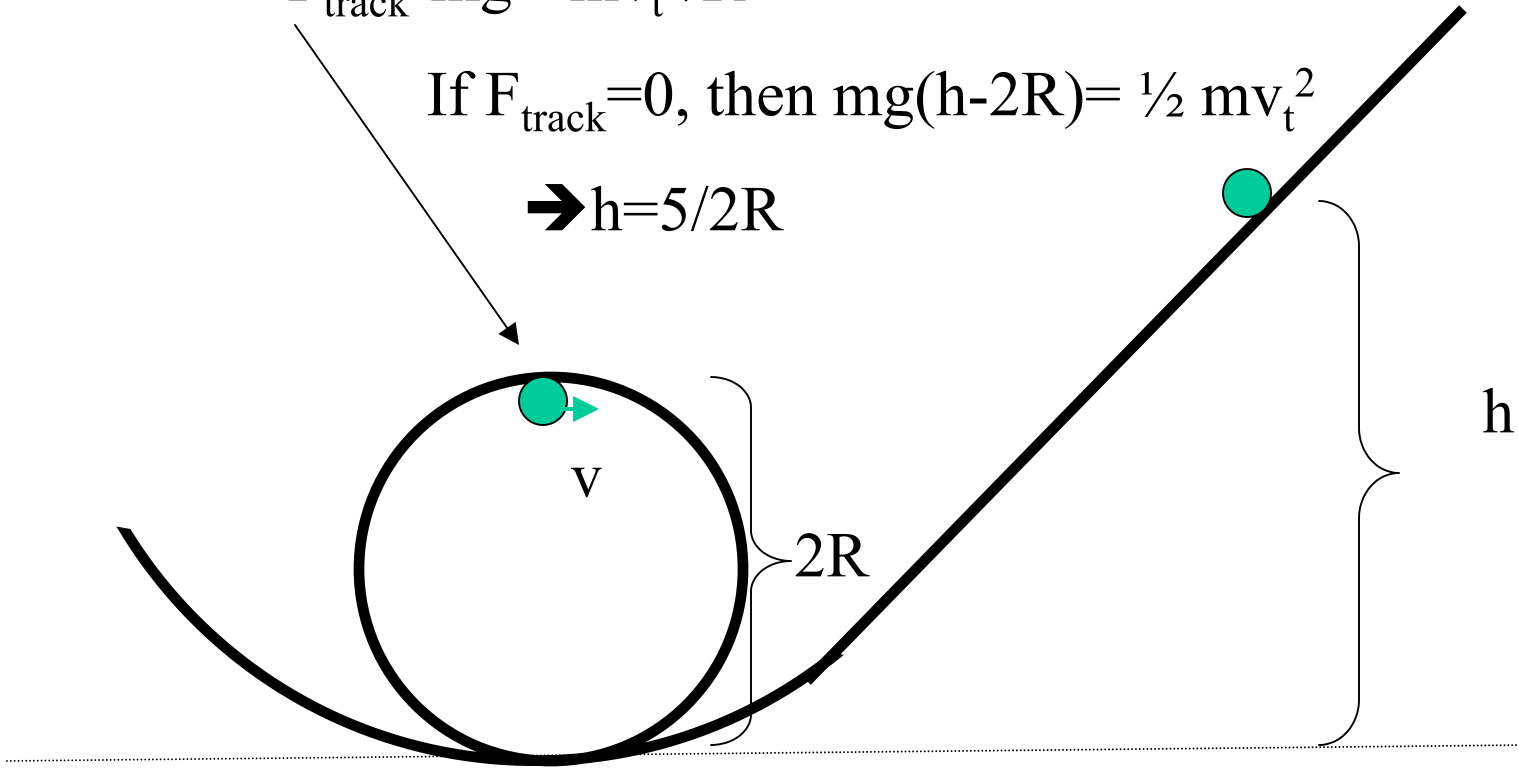
kinematic analysis: $v_f^2 = v_i^2 + 2a_0(x_f - x_i) = 2(g\sin\theta - \mu_k g\cos\theta)L$

energy analysis: $W_{total} = mgh - \mu_k mg\cos\theta L = \frac{1}{2} mv_f^2$

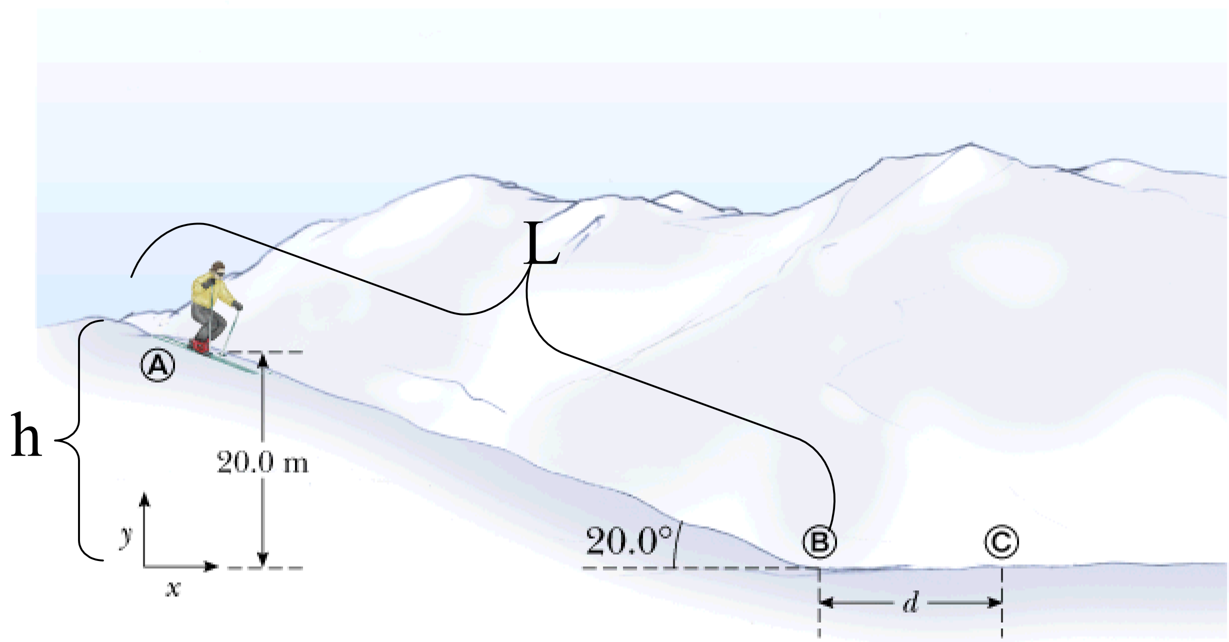
$-F_{track}-mg=-mv_t^2/R$

If $F_{track}=0$, then $mg(h-2R)= \frac{1}{2}\, mv_t^2$

➔ $h=5/2R$



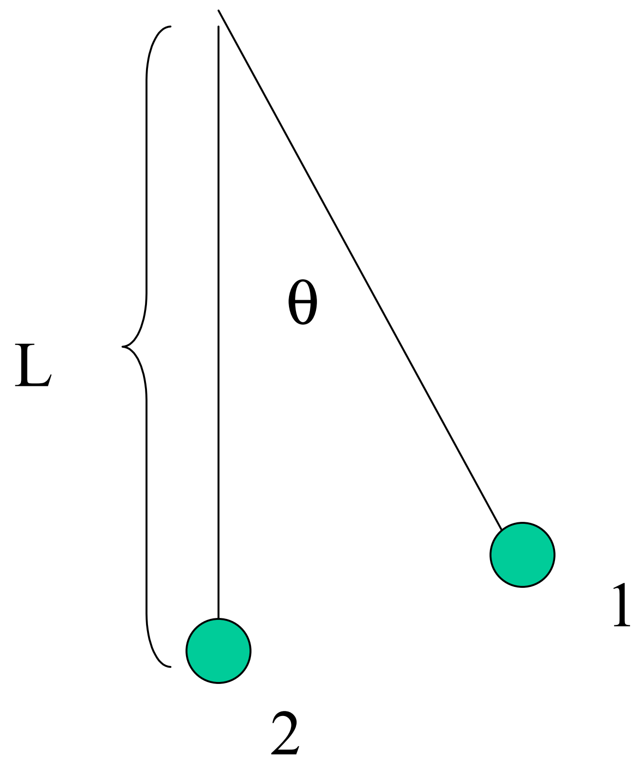
Serway, Physics for Scientists and Engineers, 5/e
Figure 8.10



Suppose that the coefficient of friction between the skiis and the snow is μ_k=0.2. What is the stopping distance d?

$$mgh - \mu_k mg\cos\theta L - \mu_k mgd = 0$$

$$d = h/\mu_k - L\cos\theta$$



A ball attached to a rope is initially at an angle θ. After being released from rest, what is its velocity at the lowest point 2?

$$\sqrt{2gL(1-\cos\theta)}$$