

# RECITATION QUESTIONS

## WEDNESDAY, 20 MARCH

1. The work-energy theorem,  $\Delta KE = \vec{F} \cdot \Delta \vec{s}$ , is closely related to the “third kinematics relation”,  $v_f^2 - v_i^2 = 2a\Delta x$ . How are they related? How is the work-energy theorem more general and more powerful? Discuss this with your group, and call your TA or coach over when you have an answer and discuss it with them.
2. Think of a situation in which:
  - (a) Kinetic friction does positive work
  - (b) Static friction does positive work
  - (c) Air resistance does positive work
  - (d) A normal force does negative work
  - (e) A normal force does positive work
  - (f) Tension does positive work
  - (g) Tension does negative work
  - (h) Tension does zero work
  - (i) Traction does zero work

To solve all parts of the following two problems, take the following steps:

- (a) Draw clear cartoons of your “before” and “after” situations. (One of the biggest sources of mistakes is not being explicit about the two pictures that you are considering with the work-energy theorem.)
- (b) Think carefully about all forces that do work on the object in question between the “before” and “after” states.
- (c) Write down the work-energy theorem:

$$\frac{1}{2}mv_0^2 + \text{work done by force 1} + \text{work done by force 2} + \dots = \frac{1}{2}mv_f^2$$

- (d) Determine the work done by each force, as either:
  - Work equals the component of the force parallel to the motion, multiplied by the distance moved:  $W = F_{\parallel}d$
  - Work equals the size of the force, multiplied by the component of the distance moved parallel to the force:  $W = Fd_{\parallel}$
  - Work equals the size of the force, multiplied by the distance moved, multiplied by the cosine of the angle between them:  $W = Fd \cos \theta$
- (e) Put these expressions for work into the work-energy theorem, and solve for whatever you need to solve for.

3. Someone drops a penny of mass 2.5g off of the Empire State Building (height 380 m). It strikes the ground traveling at 50 m/s, having been slowed somewhat by air resistance.

(a) With what velocity would it have struck the ground if there were no air resistance?

(b) What was the work done by the drag force?

(c) This penny strikes the sidewalk and penetrates the surface, digging a hole 2 cm deep. What was the upward force exerted on the penny by the pavement?

4. A police officer sets up a speed trap to catch cars driving over the speed limit coming around a curve. A car comes around the curve and sees the officer, and the driver immediately slams on her brakes to slow down before the officer can take a speed reading. By the time the officer measures the car's speed, the car is traveling 25 m/s, in an area where the speed limit is 30 m/s. However, the officer pulls over the driver anyway, saying "I saw you slam on your brakes. You must have been speeding!"

The car's driver protests the ticket in court. She says to the magistrate, "Your Honor, I can prove that I never exceeded the speed limit. It's true that I slammed on my brakes out of reflex as soon as I saw the officer. But I went back and measured the marks my tires left on the ground. Those marks are only 10.6 meters long, and by braking for that distance there's no way I could have decelerated from over the speed limit down to the 25 m/s that your officer measured."

Should the magistrate believe the driver? Could the car have been speeding when she first applied her brakes? Note that you will need to figure out the frictional force applied by the car's brakes, and to do that you will need to estimate the coefficient of friction between the tires and the pavement. Hint: do you need to know the mass of the car?