Physics 140 – Fall 2007
lecture #8 : 27 Sep

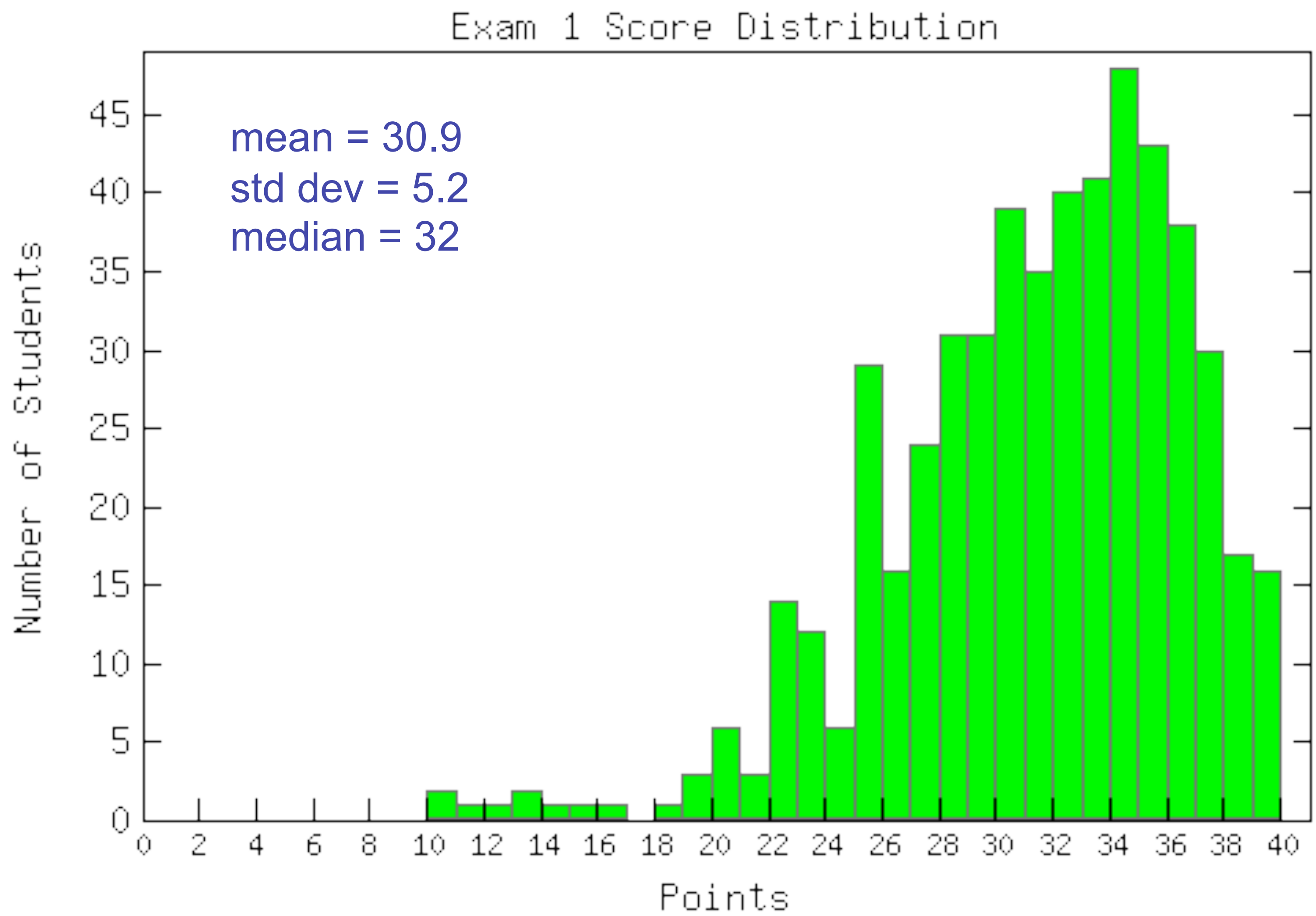
Ch 6 topics:

- work, kinetic energy

Notices:

- first midterm exam **Thursday, 4 Oct, 6:00-7:30 pm**
- **Review next TUESDAY evening (8:00 pm)**

Grade distribution of practice midterm (@2pts/problem)



Why do you write to me, “God should punish the English”? I have no close connection to either one or the other. I see only with deep regret that God punishes so many of his children for their numerous stupidities, for which he himself can be held responsible; in my opinion, only his nonexistence could excuse him. (to a Swiss colleague, 1915)

The meaning of the word “truth” varies according to whether we deal with a fact of experience, a mathematical proposition, or a scientific theory. “Religious truth” conveys nothing clear to me at all.

My comprehension of God comes from the deeply held conviction of a superior intelligence that reveals itself in the knowable world. In common terms, one can describe it as “pantheistic” (Spinoza).

Source: The Scientific Monthly (1920)

The New Quotable Einstein, A. Calaprice, ed., Princeton Univ. Press, 2005, pp. 193-5.

Work

Work is a measure of the *energy* transferred to or from a system through the action of forces.

Given a constant force $\mathbf{F}$ applied as an object moves through a displacement $\mathbf{d}$, we define the *work done, W ,* on the object by the applied force as *the scalar product of the force and displacement* vectors

$$W = \mathbf{F} \bullet \mathbf{d}$$

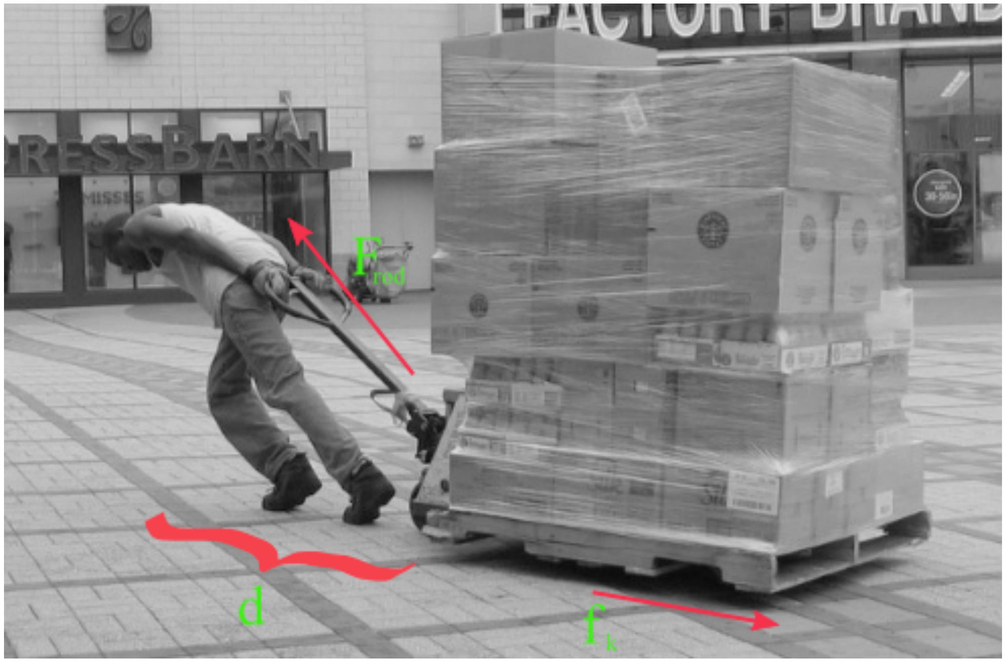
This is equivalent to $W=F_{||}d$, where $F_{||}$ is the component of the force directed *along the direction of the displacement*.

Alternately, the work is $W=Fd_{||}$ where $d_{||}$ is the component of the displacement directed *along the direction of the force*.

The SI unit of work is the *Joule* (1J = 1Nm).

Note: 1 (food) Calorie = 4,184 Joules = 4.184 kJ

Work from multiple sources



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$$W_{tot} = W_{rod} + W_{friction}$$

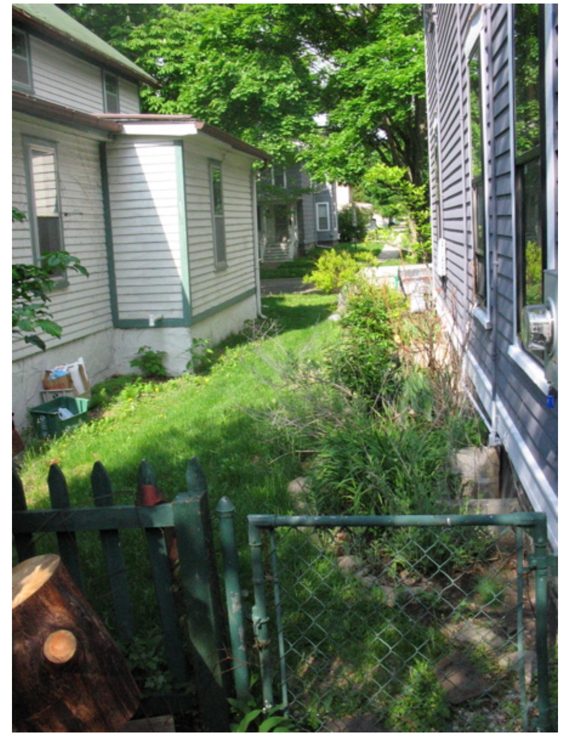
$$W_{rod} = \boldsymbol{F}_{rod} \bullet \boldsymbol{d} > 0$$

$$W_{friction} = \boldsymbol{f}_k \bullet \boldsymbol{d} < 0$$

Work is a ***scalar quantity*** that can be ***positive***, ***negative***, or ***zero*** depending on the relative orientations of ***F*** and ***d***.

As the chest moves to the right in this diagram, tension in the rope is doing positive work on the chest, while kinetic friction is doing negative work on it.

Work is moving 7.5 tons of stone!



15,000 lbs on 5 pallets
378 pavers/pallet (~3.5 kg each)
32 pavers/trip ~ 12 trips/pallet

First 2 pallets: ~750 pavers
~0.2m distance with force~mg
(m=3.5 kg)
Approximate Total Work
=750*(3.5kg*10m/s^2)*0.2m
~ 5.2 kJ ~ 1.2 Calorie
(1 Krispy Kreme sugar donut has 200 Calories!)

3 tons down, 4.5 more to go…

A tow-truck is towing a car up a steep 20 deg incline. The tow line makes an angle of 30 deg with the incline. If T is the tension in the line, what is the work done by tension on the car as it is towed a distance d along the hill?

1) $T\,d$
2) $T\cos(20)\,d$
3) $T\cos(30)\,d$
4) $T\cos(50)\,d$
5) $mg\,d$

Kinetic energy and the work-kinetic energy theorem

The energy of motion is known as *kinetic energy*. A mass m moving with velocity v has an amount of kinetic energy

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

Kinetic energy can be changed by the action of forces.

The *work-kinetic energy theorem* states that the *change in kinetic energy* over some time interval $\Delta t = t_f - t_i$ *equals the total work done*

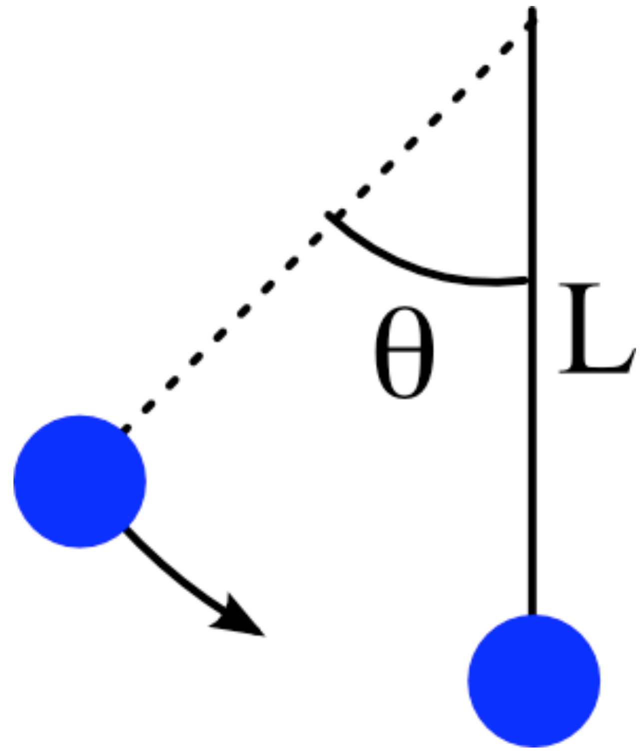
$$W_{\text{tot}} = \Delta K = K_f - K_i = \frac{1}{2} m v_f^2 - \frac{1}{2} m v_i^2$$

Here v_f and v_i are the final and initial speeds of the object of mass m, and W_{tot} is the work done by the net force acting on the object over the time interval Δt.

Lance Armstrong

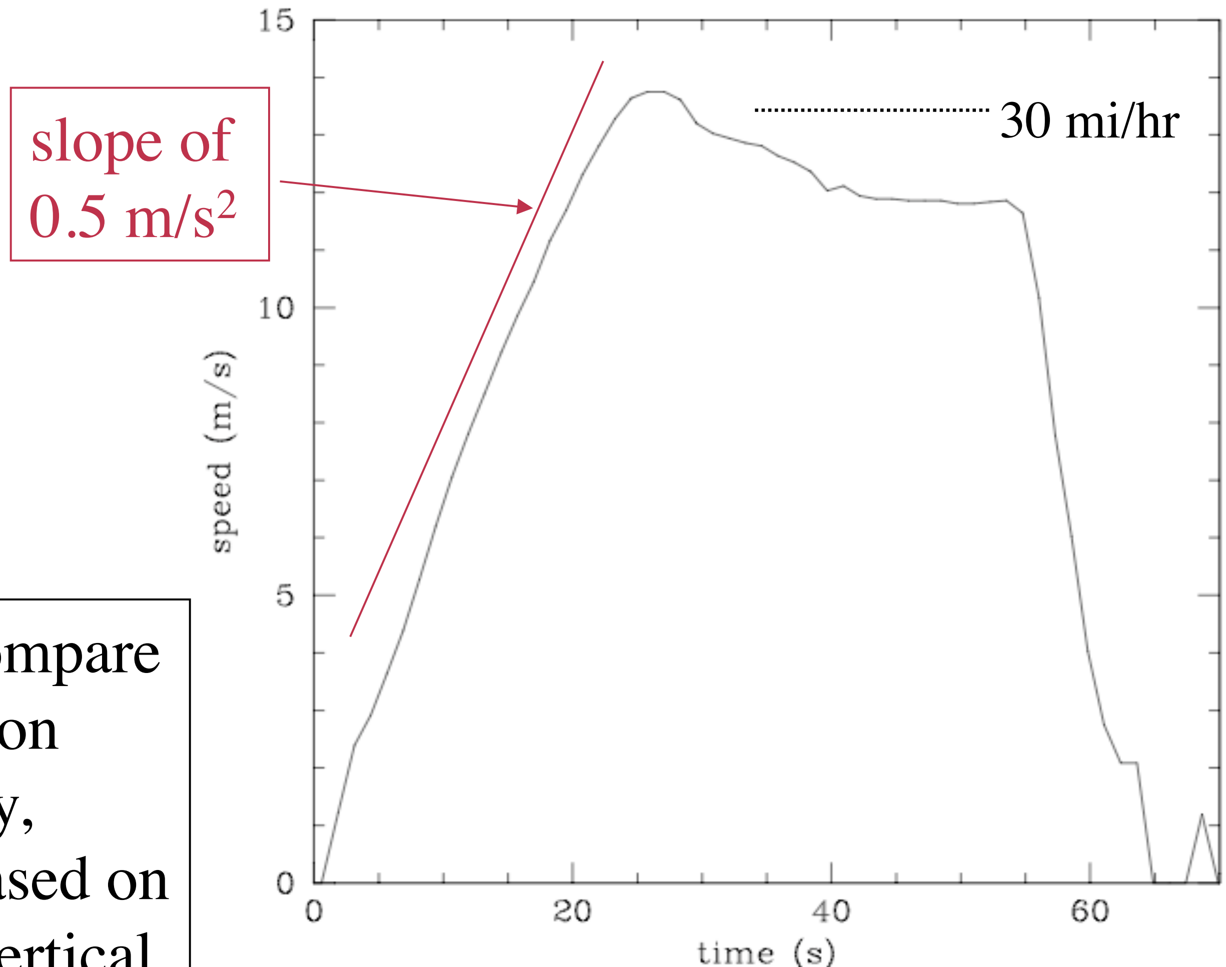
Basic idea: maximize speed/kinetic energy by minimizing (negative) work done by air drag and other sources of friction and maximizing the work done by pedaling.

A pendulum consists of a ball of mass *m* suspended from a string of length *L* and negligible mass. The pendulum is extended from the vertical by an initial angle θ and then released. At the moment the pendulum passes back through the vertical, how much work has been done on the ball by the force of gravity?



1. mgL
2. $mgL \sin\theta$
3. $-mgL \cos\theta$
4. $mgL (1 - \cos\theta)$ ←
5. $mgL (\cos\theta - 1)$

powertap data from run #1



exercise: compare to expectation from gravity, g*sin(θ), based on Beal Ave. vertical profile