Mostly Chapter 6: Work, *ENERGY* & its Conservation

Outline of today's class (apart from quizzes):

Wrap up ch. 5 from last Th: any questions on Newtonian gravity?

What is work and/or energy? Physics definitions
Why so tremendously important?
Different forms of energy, particularly $E_{gravitational}$ and $E_{kinetic}$
Energy Conservation & transformations of energy

Something to ponder:
"If the world continues with its current rate of development and population growth, global energy consumption is projected to expand by 350% by 2100! Few credible options are available to meet that need, so we'd better find some sustainable solutions.

Quiz #34: If Earth collapsed from its present 6000 km radius to only 6 km (without shedding any mass), your weight on the new surface would be
(a) 1000 times your present weight
(b) 1/1000th of your present weight
(c) unchanged
(d) 1/100,000 of your present weight
(e) 1,000,000 times your present weight

Clarify internal friction in car – last point on last slide from last class

Energy Conservation is among the broadest and therefore most important physical principles known.

Principles of energy & energy conservation are universally valid, far beyond Newtonian confines.

Energy = "capacity to do work", quantitatively "the amount of work a system *can/could* do." (emphasis on *can/could* !)
→ Humankind's history and what we call civilization are intimately intertwined and nearly synonymous with the use of (mostly solar) energy.

Work = ? Need a useful definition…examples (Figs. 6.1-3), demos.

work = force × distance (in the sense of displacement – bit tricky: only component of force in direction of displacement, but we'll stay with parallel situations) – important: doing work *on* something.
Units for work (and later energy): N m = J(oule)

Concept Checks (always study carefully!) 4 – 6.

Quiz # 35: As above let's carefully consider force(s), net force, and work done on an object.
You lift, slowly & steadily (i.e. at constant speed), an object weighing 10 N from the floor up 1.5 m. Ignore air resistance.

While you're lifting, there are … forces on the object, the net force on the object is …, the force by your hand on the object is …, and once you're done lifting, you will have done … work on the object

(a)	0,	0 N,	10 N,	10 J (1 Joule = 1 N m)
(b)	1,	10 N,	10 N,	15 J
(c)	2,	0 N,	10 N,	15 J
(d)	2,	10 N,	0 N,	0 J
(e)	1,	0 N,	10 N,	15 J

Work & Energy (E), i.e. the capacity to do work: examples & demos

Keep in mind: *energy* E = amount of work a system *can* do.
Example: tank of gasoline – “chemical” E, which can be *transformed* into other forms of E.

Remember: When A exerts force on B, while B gets displaced, A does work on B. As we’ll see, this work amounts to an energy transfer, i.e. B’s energy content will *increase*.
Work & energy are not vectors, i.e. no directional content.

C.E. 2 / 4

Answers: a meter high / rub hands together, heat water, slide something across a surface,…

Quiz #36: An airplane does 40 million J of work during takeoff, traveling for 1 km. Total engine thrust? Careful about units!

(a) 10^4 N

(b) 4×10^4 N

(c) 40 million N

(d) 40,000 J

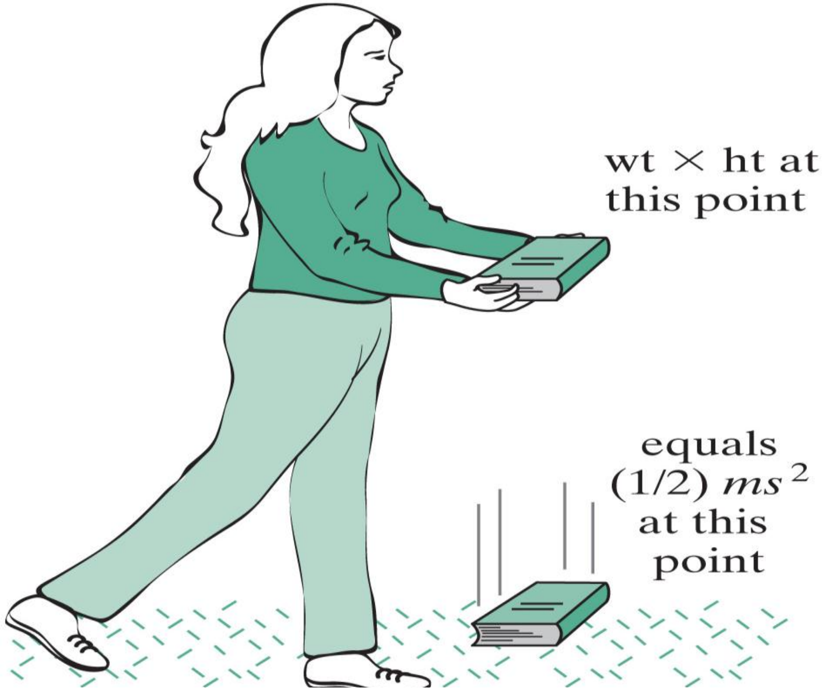
(e) 4×10^4 J

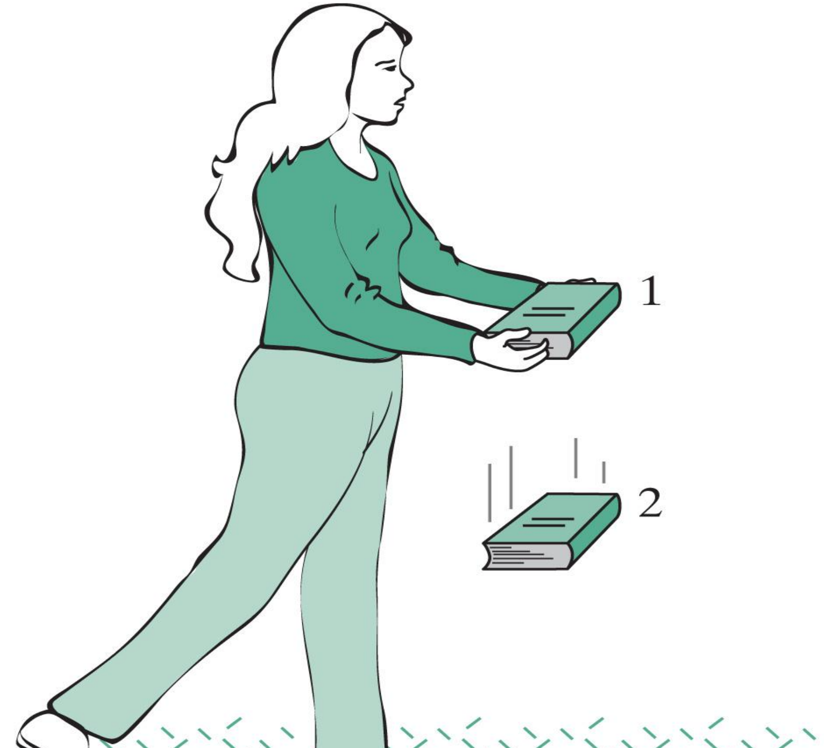
Two particularly important forms of energy:

$E_{kinetic}$ & $E_{gravity}$ (also called gravitational "potential" energy)

$E_{gravity}$ = weight × height = m × g × h (h relative to some reference point – elaborate!) – E of any raised object.

$E_{kinetic} = (1/2) \times m \times v^2$ (safe to use speed for v) – answer to: how much work can a moving object do because of its motion? Derivable from Newton's Laws.





Remarkable fact (provable from Newton's Laws & experimentally testable, neglecting air resistance, dropped from rest):

$$mgh = (1/2)\, mv^2_{bottom}$$

(use v, not s!)

<u>Note</u>:

This is <u>Energy Conservation</u> in the sense that $E_{total} = E_{grav} + E_{kin} = \text{const.}!$

But also <u>Energy Transformation</u> !

h is just the vertical displacement top to bottom (which is the reference point), regardless of where h is relative to the ground.

m drops out of the above equation! What then does v depend on, only?

Remember hammer & feather on moon?

Let's evaluate this energy transformation of a falling object:

$mgh = \frac{1}{2} mv^2$ → $v = \sqrt{2gh}$, i.e. only depends on h.

$E_{kinetic}$ increases with the *square* of v → significant societal or everyday consequences – good and bad – examples?

Quiz # 37: An object weighing 20 N is dropped from a height of 2 m (starting from rest, of course, and we ignore air resistance). At 1 m above the floor, its $E_{gravitational}$ (relative to the floor) and its E_{kin} are, respectively,

(a) 40 J and 0 J.
(b) 20 J and 20 J.
(c) 0 J and 20 J.
(d) 20 J and 0 J.
(e) 10 J and 30 J.