Finish chapter 6: Work, Energy (incl. conservation), Power……then start ch. 7 on the famous 2nd Law of Thermodynamics

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

More examples of importance & relevance of E conservation & transformations & work – energy theorem
Different forms of energy – mass **is* energy too!
Power

2nd Law of Thermodynamics – "$E_{thermal}$ is special!"

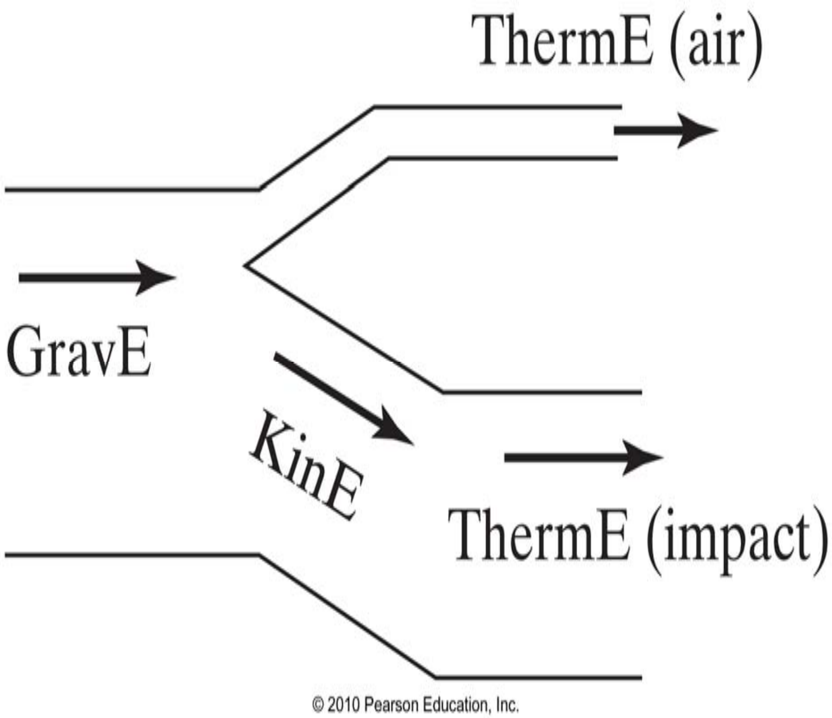
Worth remembering:

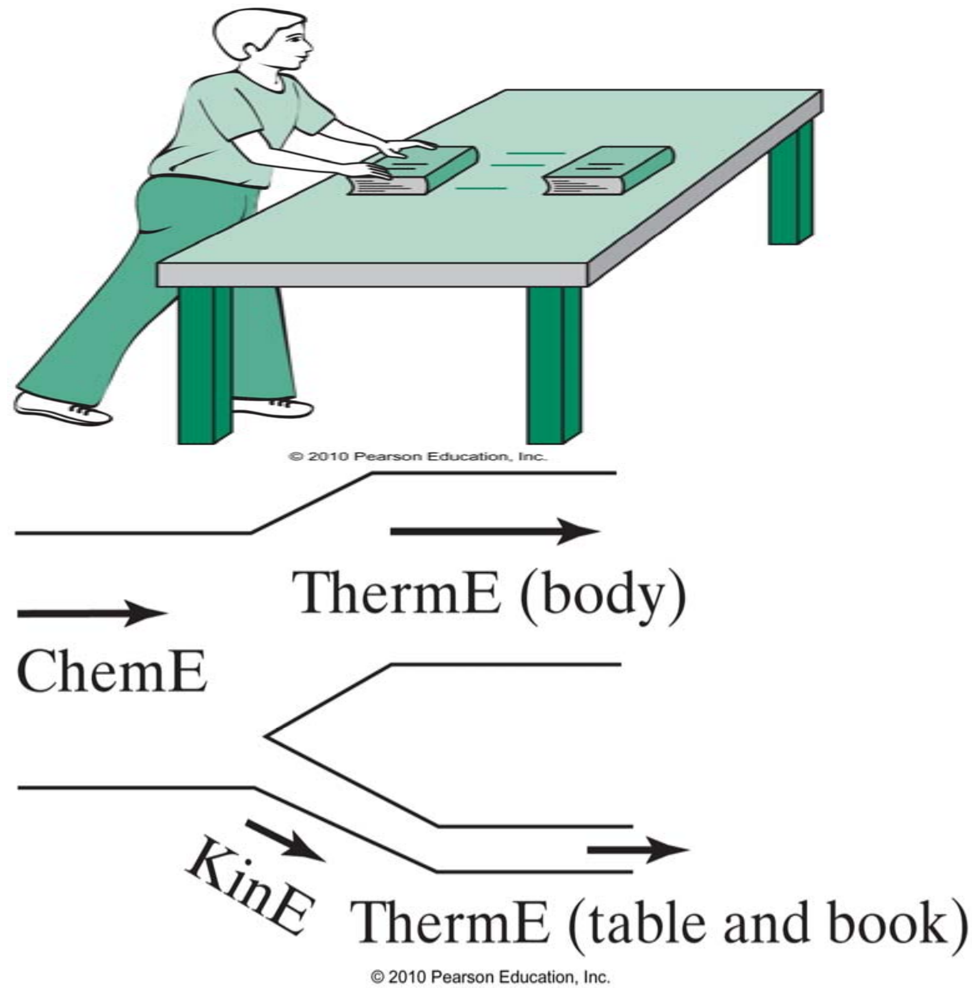
There are many different types of E(nergy).
(Doing) work or heating are E *transfers/transformations*.

Note the importance of E transformations & E flow: if you look closely, almost every process can be described in such terms.

Good example: automobile….let's discuss…

Dropping an object, which then comes to rest:





Notice a theme?

Over & over you end up with at least some $E_{thermal}$ (heat)! → Ch. 7

<u>Quiz # 42</u>: What is the E flow in a car that is driven <u>uphill</u> at constant speed? Do <u>not</u> neglect friction.

(a) kinetic → gravitational & thermal
(b) chemical → kinetic & gravitational
(c) gravitational → kinetic & thermal
(d) chemical → thermal & gravitational
(e) none of the above is correct

<u>Quiz # 43</u>: Any *fundamental* (qualitative, not quantitative) change in the above E flow if the car is accelerating?

(a) no
(b) yes
(c) depends on how lead-footed the driver is

Problem 7: Ah, where to start?

How about with $F_{airresistance}$ *on* Ned? Must be 600 N.

Now what? F by Ned *on* air also 600 N – Newton's 3rd!

Thus $W = Fd = 600 \text{ N} \times 200 \text{ m} = 1.2 \times 10^5 \text{ J}$

Problem 8: Into heating the air, i.e. into thermal E.
Comes from Ned's gravitational E.

Make sure to go through Concept Checks 13 – 15.

E efficiency = useful output E/total input E
As you'll see, often remarkably low.

Power P = time rate of transforming E (or doing work), i.e.

$P = E/t$ Units: J(oule)/s(econd) = W(att)   (kW, MW, etc.)

Rate at which a device "uses" (i.e. transforms) E(nergy).

Clear difference between E and P: running vs. walking up stairs.

Table 6.1

Power consumption of household appliances while the appliance is turned on and consuming electric energy

Appliance	Power (W)
Cooking range	12,000
Clothes dryer	5,000
Water heater	4,500
Air conditioner, window	1,600
Microwave oven	1,400
Dishwasher (incl. hot water)	1,200
Toaster	1,200
Hair dryer	1,000
Refrigerator, frostless	600
Refrigerator, not frostless	300
TV, color	350
Stereo set	100

Any Conclusions?

Heating with electricity is costly!

Why does PNM charge you for "kW-hours"?

Because that's the energy you used, and (at least in general) PNM cares more about your E usage than your P usage.

Get a good feel for 1 kWh:
1000 W for 1 hour = 1000 W × 3600 s = 3.6 MJ (3.6×10^6 J)
What can you accomplish with 3.6 MJ = 3.6×10^6 Nm of energy?
Lift an 1800 kg car (weighing 18,000 N) by 200 m!

And that for <10 cents in NM! Electricity is *much* too cheap here!

Average US household: ~ 1,000 kWh per month (very wasteful)

C.E. 46: P = 0.3 kW, runs for 8 × 30 = 240 hrs/month, thus E consumed is 0.3 kW × 240 hrs = 72 kWh, or $7.20 at $0.1/kWh
Frostless about twice that much.

C.E. 48: Clothes dryer equivalent to about 5 kW/100 W = 50 100 W lightbulbs.

Quiz # 44: You lift books onto a table, one by one. They all end up on the same surface, next to each other. After a while, you slow down. As you slow down, the *energy E* and *power P*, respectively, that you put into lifting each book

(a) both remain the same

(b) increases (E), remains the same (P)

(c) both increase

(d) remains the same (E), decreases (P)

(e) decreases (E), remains the same (P)

<u>Problem 21</u>: Need to assume that *all* the work goes into E_{kin}. Remember the work - energy theorem!

E_{kin} = (1/2) mv^2 = 30 kg × $(10\ m/s)^2$ = 3 kJ

P = E/t (or W/t) = 3 kJ / 2 s = 1.5 kW

Follow-on <u>Quiz # 45:</u>

What if acceleration were from 5 m/s to 10 m/s? That would require (remember: work put into object = energy increase of object)

(a) half the above power

(b) less than half (why? – to be discusses afterwards)

(c) more than half (why? – again, later)

Hint: always remember how $E_{kinetic}$ scales with v(elocity).

Let’s calculate! E_{kin} @ 5 m/s vs. 10 m/s, that difference is the amount of W needed……P = 1.125 kW

Quiz # 46: Consider a small and a large ball of the same material, and neglect friction. Both start (from rest) to roll down an incline, for only one second. At this instant, the large ball will have a greater

(a) gravitational (potential) energy.
(b) kinetic energy.
(c) speed.
(d) all of the above.
(e) both (a) and (b) are correct

Follow-on: What would you need to know or measure in order to calculate v at that instant?

Quiz # 47: Which task requires more power? Lifting a 50 kg sack 2 m in 2 s, or a 25 kg sack 2 m in 1 s?
(a) the 50 kg sack.
(b) the 25 kg sack.
(c) both the same.
(d) impossible to determine without knowing the sack’s contents