

I TRY NOT TO MAKE FUN OF PEOPLE FOR ADMITTING THEY DON'T KNOW THINGS.

BECAUSE FOR EACH THING "EVERYONE KNOWS" BY THE TIME THEY'RE ADULTS, EVERY DAY THERE ARE, ON AVERAGE, 10,000 PEOPLE IN THE US HEARING ABOUT IT FOR THE FIRST TIME.

FRACTION WHO HAVE HEARD OF IT AT BIRTH = 0%  
FRACTION WHO HAVE HEARD OF IT BY 30  $\approx 100\%$   
US BIRTH RATE  $\approx 4,000,000/\text{year}$   
NUMBER HEARING ABOUT IT FOR THE FIRST TIME  $\approx 10,000/\text{day}$

IF I MAKE FUN OF PEOPLE, I TRAIN THEM NOT TO TELL ME WHEN THEY HAVE THOSE MOMENTS. AND I MISS OUT ON THE FUN.

"DIET COKE AND MENTOS THING"? WHAT'S THAT?

OH MAN! COME ON, WE'RE GOING TO THE GROCERY STORE.

WHY?

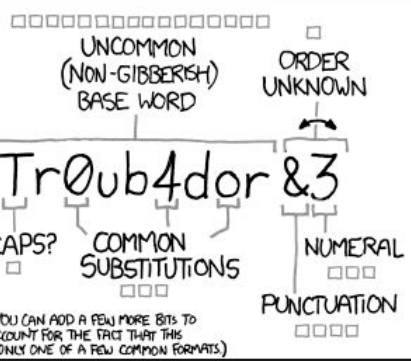
YOU'RE ONE OF TODAY'S LUCKY 10,000.



# PHY151 Practical 6

Your pod number has changed! Check under the "Pod Number" column in your grades for the course on quercus, this will tell you where to sit.

Some statistics jokes for today...



~28 BITS OF ENTROPY

2<sup>28</sup> = 3 DAYS AT 1000 GUESSES/SEC

(PLAUSIBLE ATTACK ON A WEAK REMOTE WEB SERVICE: YES, CRACKING A STOKEN HASH IS FASTER, BUT IT'S NOT WHAT THE AVERAGE USER SHOULD WORRY ABOUT.)

DIFFICULTY TO GUESS: EASY

WAS IT TROMBONE? NO, TROUBADOR. AND ONE OF THE O'S WAS A ZERO?

AND THERE WAS SOME SYMBOL...

DIFFICULTY TO REMEMBER: HARD

correct horse battery staple

FOUR RANDOM COMMON WORDS

~44 BITS OF ENTROPY

2<sup>44</sup> = 550 YEARS AT 1000 GUESSES/SEC

DIFFICULTY TO GUESS: HARD

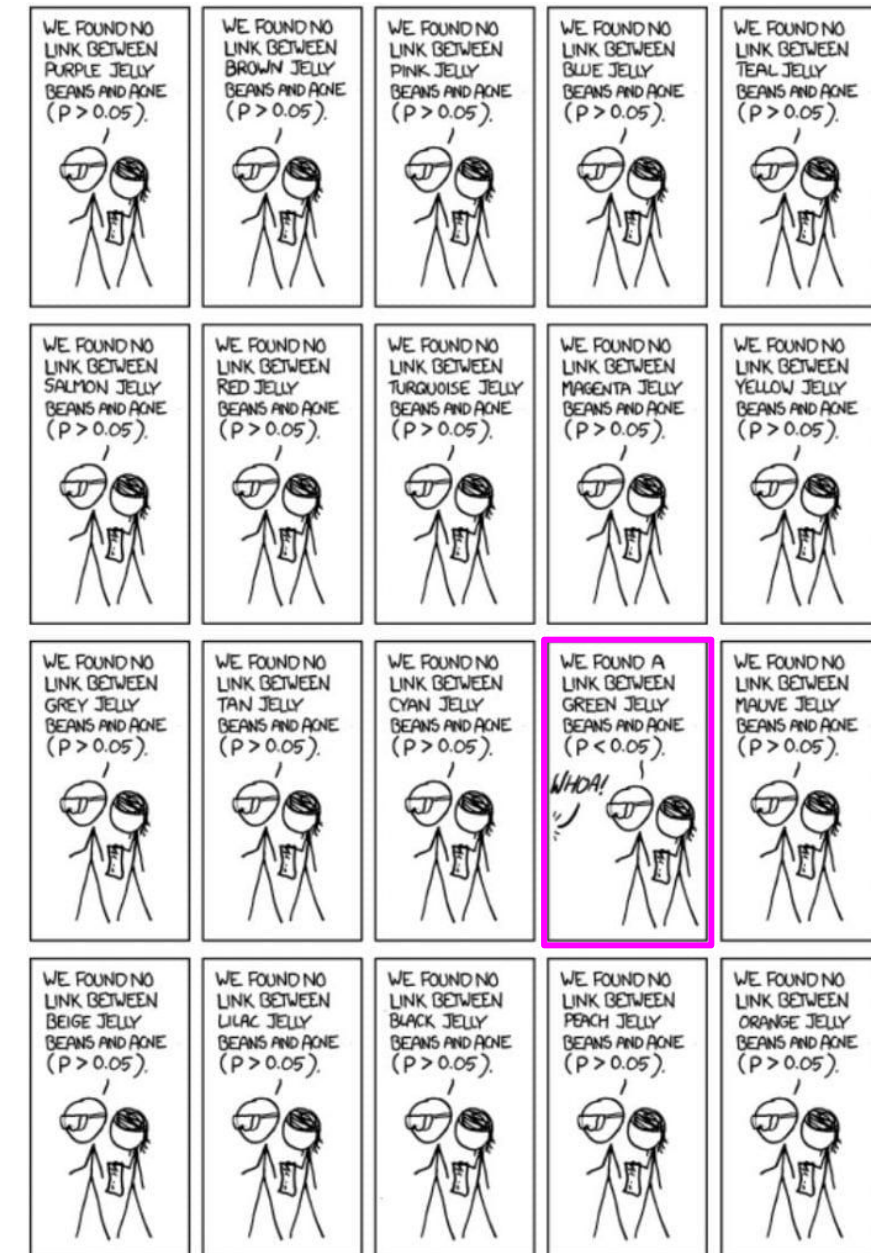
THAT'S A BATTERY STAPLE.

CORRECT!

DIFFICULTY TO REMEMBER: YOU'VE ALREADY MEMORIZED IT

$$P(\text{I'M NEAR THE OCEAN} \mid \text{I PICKED UP A SEASHELL}) = \frac{P(\text{I PICKED UP A SEASHELL} \mid \text{I'M NEAR THE OCEAN}) P(\text{I'M NEAR THE OCEAN})}{P(\text{I PICKED UP A SEASHELL})}$$

STATISTICALLY SPEAKING, IF YOU PICK UP A SEASHELL AND DON'T HOLD IT TO YOUR EAR, YOU CAN PROBABLY HEAR THE OCEAN.



A p value of 0.05 means there's a 1 in 20 chance that there's a correlation. It's important to understand statistics. Also don't use p values.

THROUGH 20 YEARS OF EFFORT, WE'VE SUCCESSFULLY TRAINED EVERYONE TO USE PASSWORDS THAT ARE HARD FOR HUMANS TO REMEMBER, BUT EASY FOR COMPUTERS TO GUESS.

# Outline for Today

- First 50 minutes: Practice problems
  - Prof. Wilson has written 4 problems similar to those on tests. Please work *together* on these (*not for marks*)!
- Final 2 hours: working on the Practical Activities of the week.
  - Write-ups in the TERM booklets **for marks**
  - Mechanics Module 5: Activities 14-17 (3 and 11 if you have time)

# Last week's practical

1. Suggestion: Reproduce some of the figures from the lab manual, in particular the coordinate system, this will avoid confusion and inconsistency.
2. Force diagram and potential energy: do not take absolute value of force (is generally not very helpful).

$$U(\vec{r}) = - \int_{\vec{r}_{ref}}^{\vec{r}} \vec{F} \cdot d\vec{r} \quad \leftrightarrow \quad F(\vec{r}) = -\nabla U$$

For the question in 1d spring, with  $F = -k(x - x_0)$  and hence

$$U(x) = - \int_{x_0}^x -k(x' - x_0) dx' = \frac{1}{2}k(x - x_0)^2$$

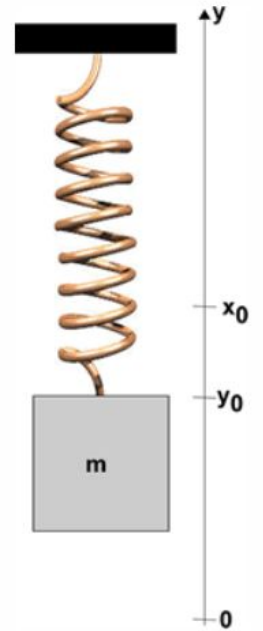
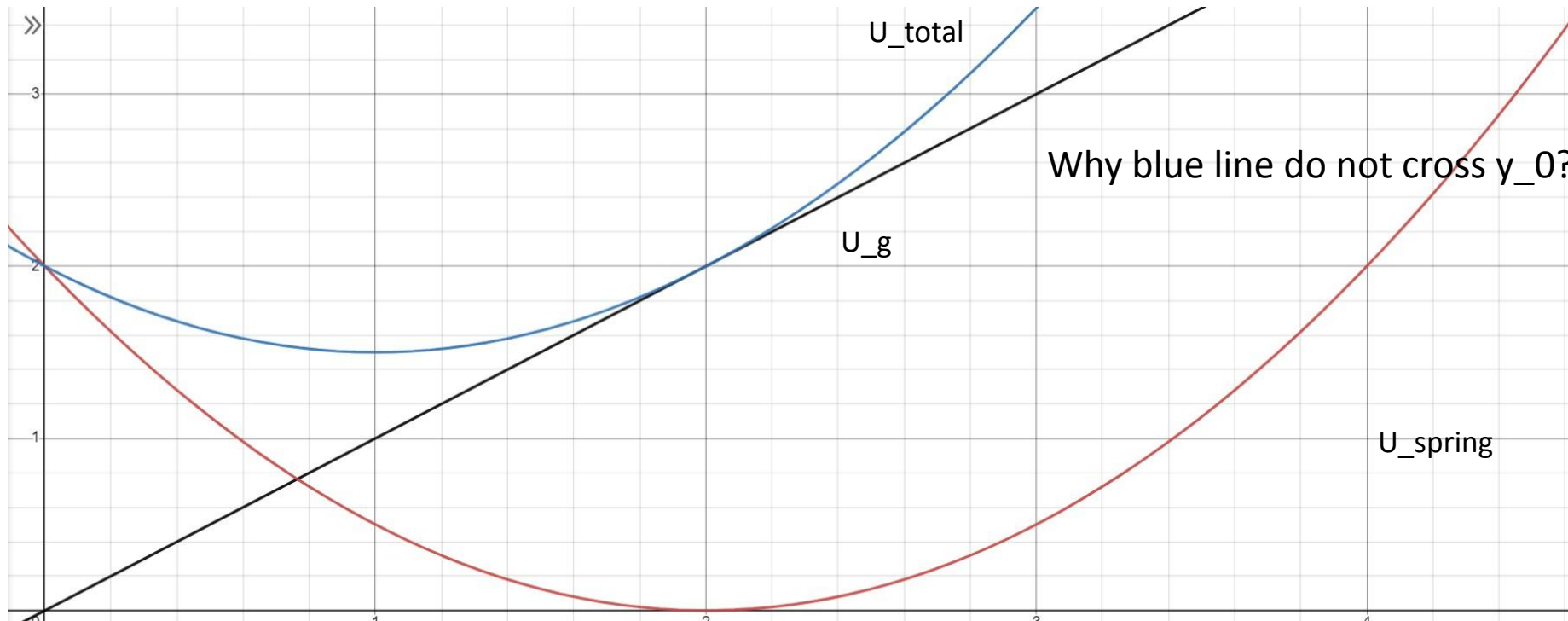
$$-k(y_0 - x_0) - mg = 0 \Rightarrow y_0 = x_0 - \frac{mg}{k} \quad (0.3)$$

And the net force is given by

$$\begin{aligned} F_{\text{Net}} &= -k(y - x_0) - mg = -k(y - x_0) + k(y_x - x_0) \\ &= -k(y - y_0) \end{aligned} \quad (0.4)$$

Then total potential energy is given by

$$U_{\text{pot}} = \frac{1}{2}k(y - y_0)^2 + \frac{1}{2}mv^2 \quad (0.5)$$



# Today's Tutorial Problems

1. Basic vector algebra
2. A classic problem: what is the condition for the sled to leave the circular hill (think about circular motion)? How does the sled's speed change? Should you think about energy or force here?
3. Estimate the mass of a person and the duration of a car crash. The rest should follow.
4. Balance the energies, and rearrange so you get a function  $h(x^2)$ . This should have a simple form, by estimating its parameters from the graph, you should be able to get  $k$ .

# Today's Tutorial Problems

1. (a)  $W = \int_0^1 (0)dy + \int_0^1 (-1)dx = -1$

(b)  $W = \int_0^1 (0)dx + \int_0^1 (1)dy = 1$

(c) The work depends on the path, so this is a non-conservative force.

2. Conserve energy to find the speed of the sled as a function of angle:

$$\frac{1}{2}mv^2 = mgR(1 - \cos \phi) \rightarrow v^2 = 2gR(1 - \cos \phi)$$

The mass 'flies off' when the normal force is zero. This is when the radial component of gravity is  $v^2/R$ , which gives

$$\frac{v^2}{R} = g \cos \phi$$

Put these together and get

$$2g(1 - \cos \phi) = g \cos \phi \rightarrow \cos \phi = \frac{2}{3} \text{ or } 48 \text{ degrees.}$$



# Today's Tutorial Problems

3. Assume the car is going 20 m/s. Assume the person's mass is 70 kg. Assume the front of the car crumples by 1 m. Assume that the seatbelt applies a force on the person for the entire 1 m of crumpling of the car. Assume the work done by the seatbelt is entirely responsible for stopping the person. Assume a constant force (so we don't have to do an integral). We get

$$\frac{1}{2}mv^2 = F\Delta x \text{ or } F = \frac{mv^2}{2\Delta x} = \frac{(70 \text{ kg})(20 \text{ m/s})^2}{2 \text{ m}} = 7000 \text{ N}$$

That's huge! That's equivalent to the weight of 700 kg. Of course, accidents are serious, so I expect huge forces. Certainly I expect a force an order of magnitude larger than gravity (700 N in this case), and my answer is an order of magnitude larger. So it's certainly believable. I expect a person could survive such a force (weight of 10 people) but they wouldn't enjoy it.

# Today's Tutorial Problems

4. Take the system to be the mass, the spring, and the Earth. This system is isolated (if we ignore air) and all forces are conservative, so we have mechanical energy is conserved. The mass begins and ends at rest, so we have energy being converted from spring energy to gravitational energy. Let  $\Delta y$  be the additional compression, let  $y_{eq}$  be the equilibrium position of the mass on the spring, and  $y$  be the height above  $y_{eq}$ . We get

$$\frac{1}{2}k(\Delta y)^2 = mgh$$

or

$$h(\Delta y) = \frac{k}{2mg}(\Delta y)^2$$

So the slope of the line gives us  $\frac{k}{2mg}$ , and therefore we want  $k = 2mg \times (\text{slope})$

I get a slope of about  $6.3 \pm 0.5$  for a spring constant of about  $250 \pm 20$  N/m.

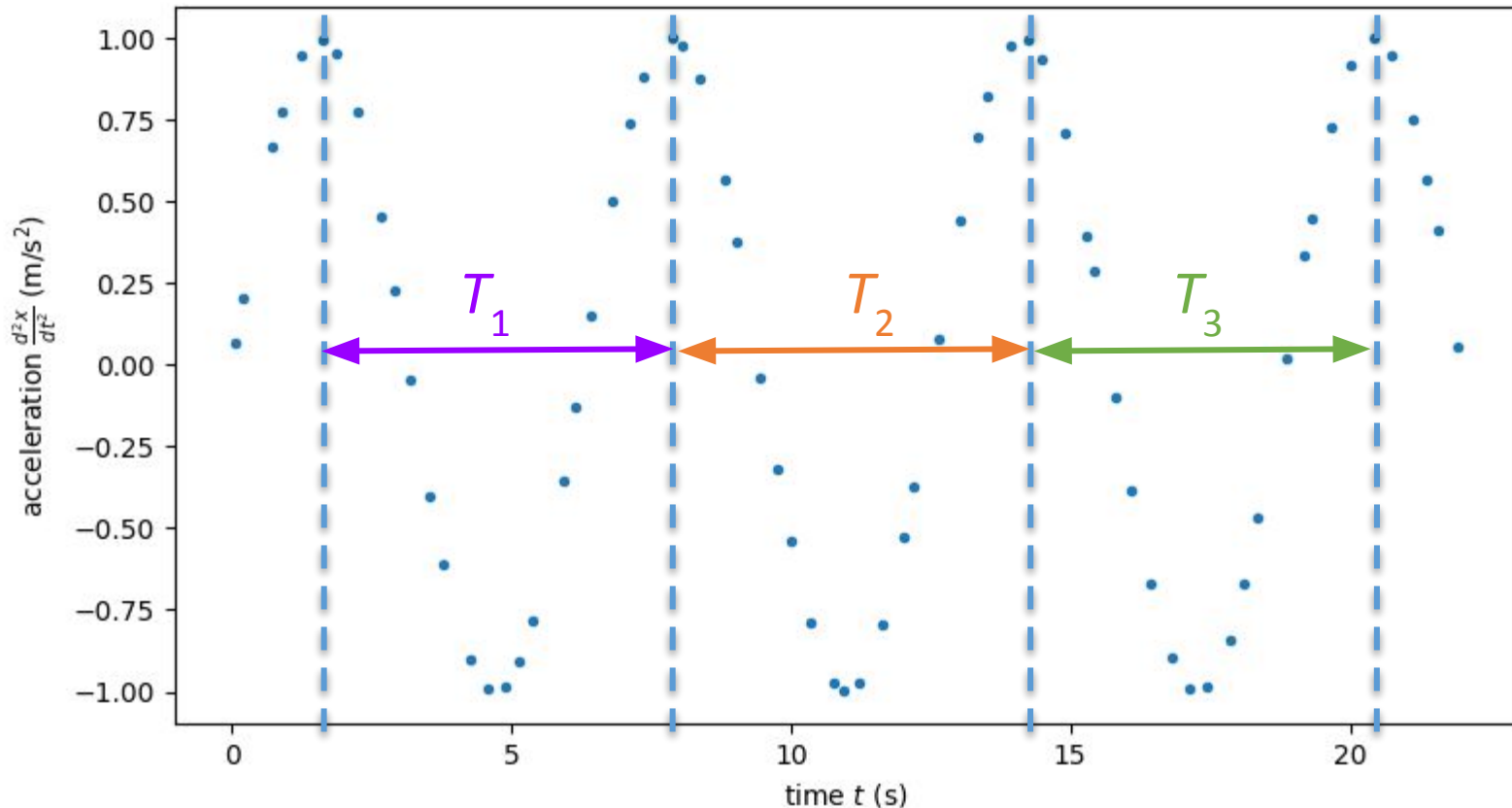


# Today's Practical

- **Mechanics Module 5: Activities 14-17** (3 and 11 if you have time)
- Avoid fully compressing the spring
- Jumpers don't stick too good no more
- Make sure ruler and jumper are in the same focal plane
- Some types of energy to think about:
  - electrostatic, chemical, gravitational & elastic potential energies
  - linear, angular kinetic energy (which include vibrations like temperature, sound, oscillations, etc.)
  - good vibes (hint, some of those listed here may not be relevant)
- Activities 15-17 are theory and should be very quick
  - Don't be confused by vectors, what it always comes down to is that work is positive if it increases the energy in the system.
  - In Activity 17, consider **only** the motion of the system in between the "before" and "after" states
  - Thinking about 17D before 17C may make it easier for you...
- The bonus activities are pretty easy this week, give them a shot!
  - For 3, think about energy
  - 11 is basically free marks
- **Cite lab manual** or write out complete procedure.
- **REFLECT ON RESULTS!!!**

# Today's Practical

- Remember: standard deviation is the uncertainty in one measurement, standard error is the uncertainty in the mean of N measurements of the same quantity.



$$\langle T \rangle = (T_1 + T_1 + T_1) / 3$$

$$\sigma^2 = \sum_i (T_i - \langle T \rangle)^2 / 3$$

$$SE = N^{-1/2} \sigma$$

So you would say a given measurement is  $T_i \pm \sigma$  and the number you report is  $T = \langle T \rangle \pm SE$