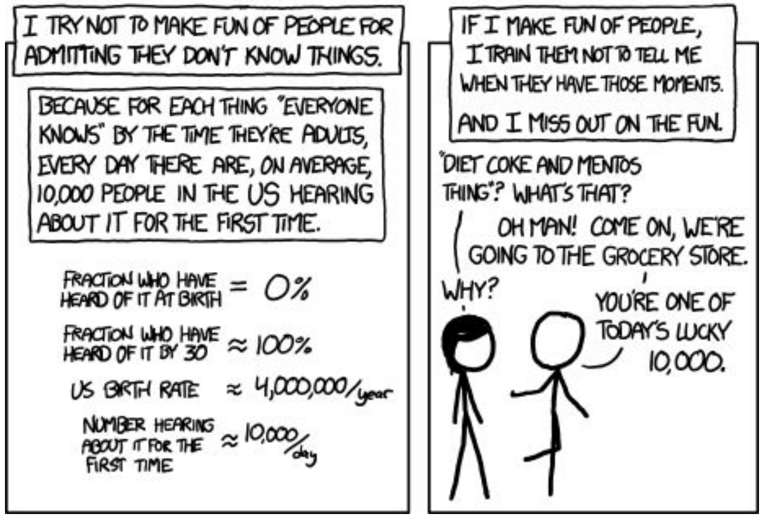
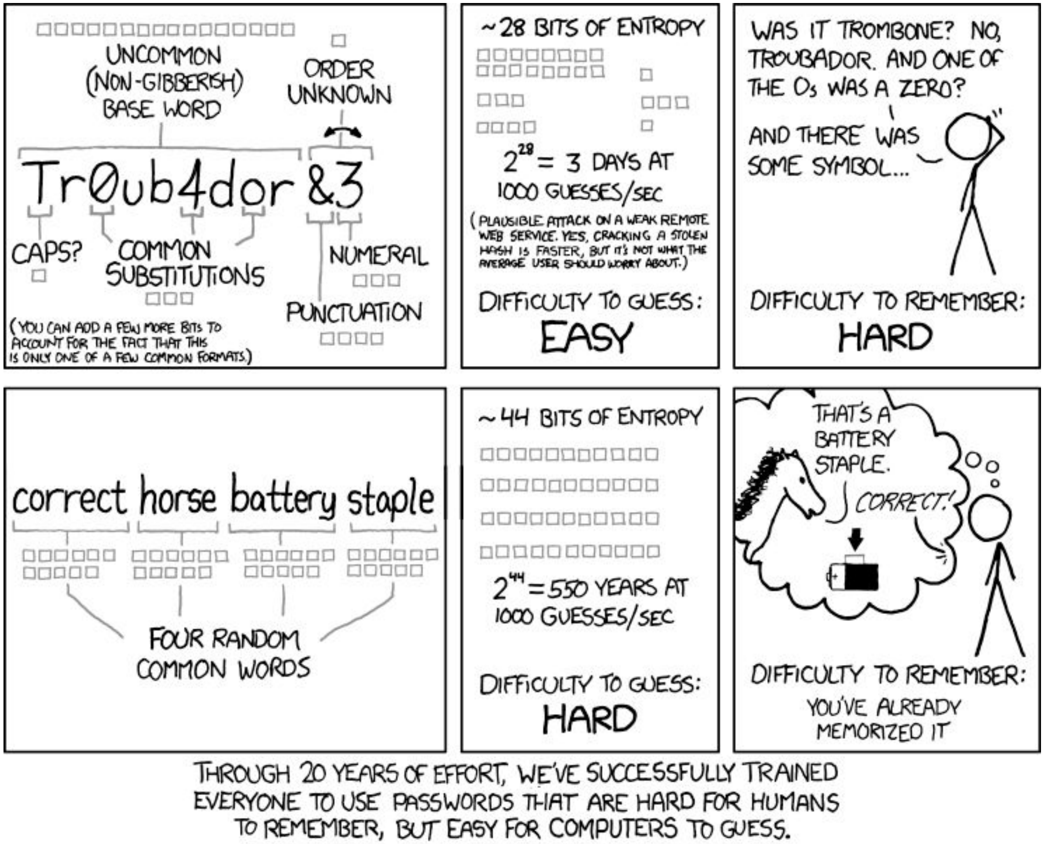
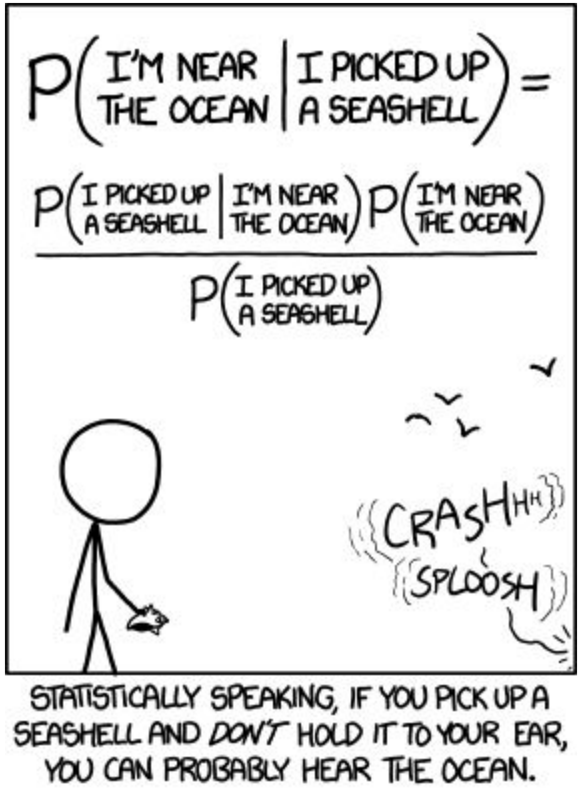
PHY151 Practical 6

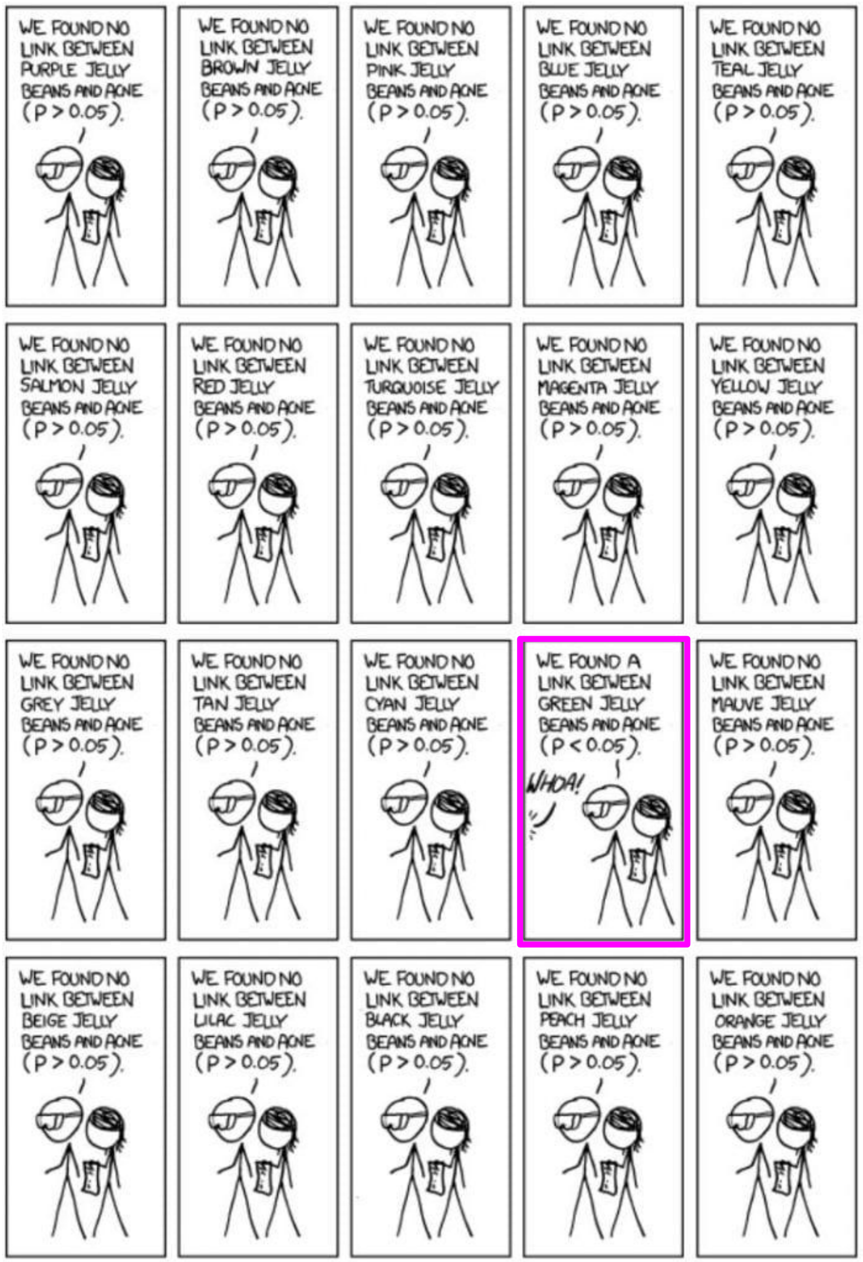


Some statistics jokes for today…

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.







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.

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

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

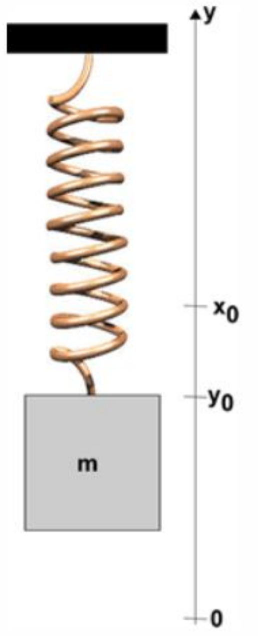
$$-k(y_0 - x_0) - mg = 0 \quad \Rightarrow \quad y_0 = x_0 - \frac{mg}{k} \tag{0.3}$$

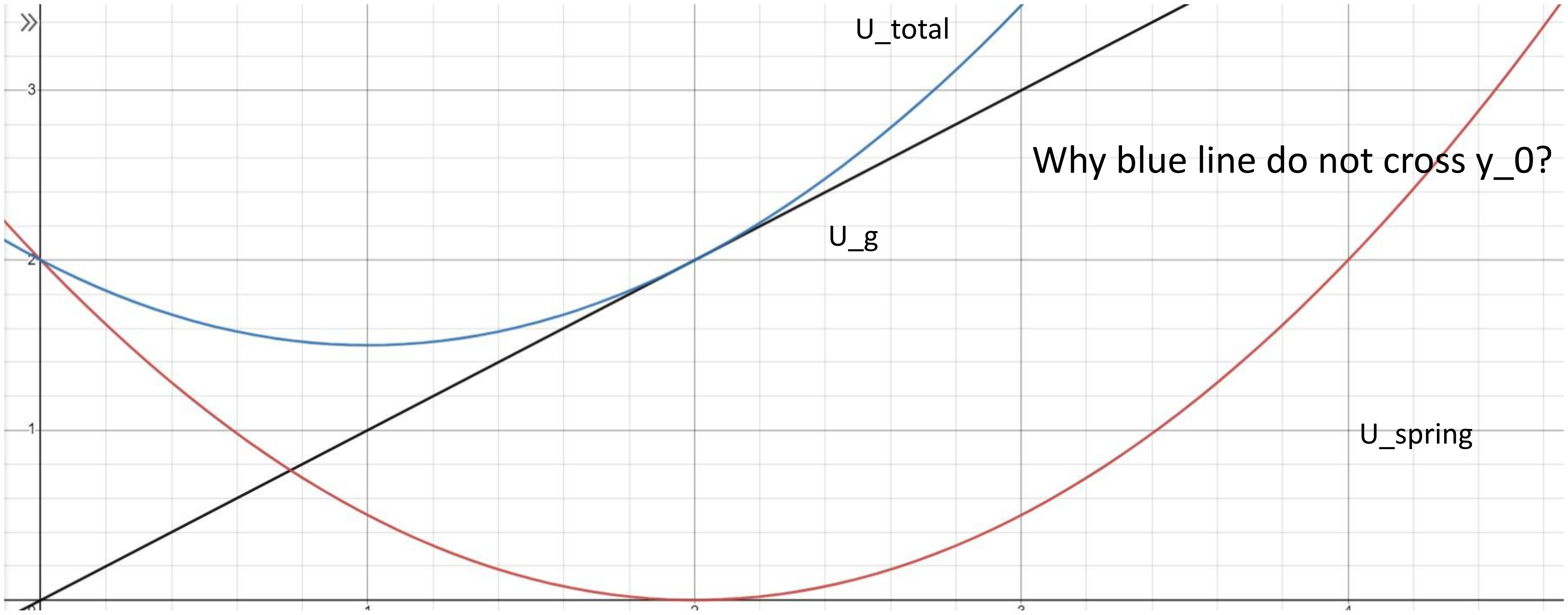
And the net force is given by

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

Then total potential energy is given by

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





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 it’s 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

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

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

   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 Δy 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 ± 0.5 for a spring constant of about 250 ± 20 N/m.

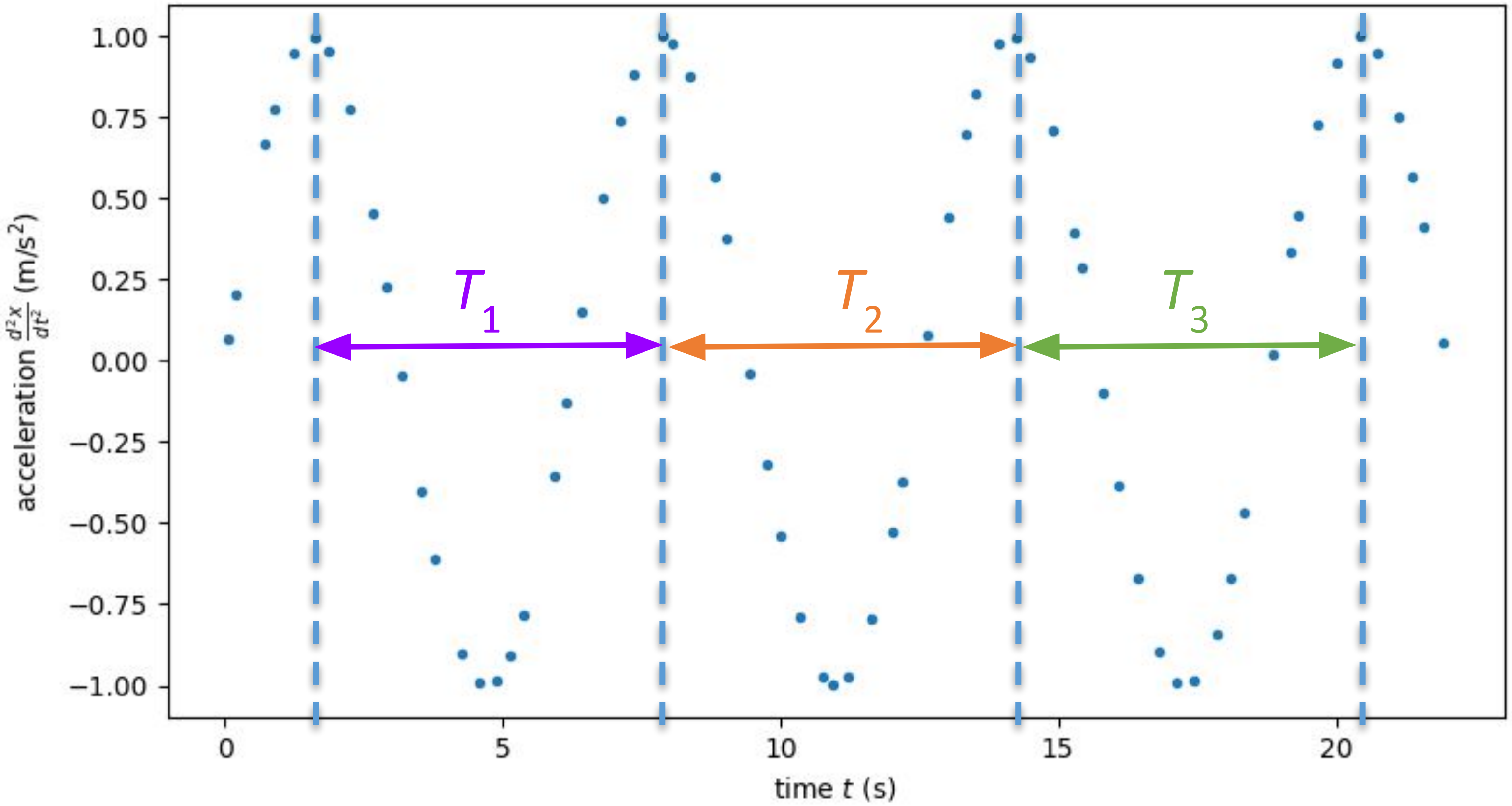
Today’s Practical

- **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.



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

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

$SE = N^{-½} \sigma$

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