Estimation

-- order-of-magnitude estimates

-- quick-and-dirty calculation

-- approximation

-- sanity checks

-- dimensional analysis

-- guesstimates (or even plain guessing)

-- simplification

When to estimate?

-- ALWAYS (any detailed calculation should really be backed up by an order of magnitude estimate, if only as a sanity check)

-- often only a rough answer is needed (e.g. no point doing a 1% integration in a problem where some parameter may only be known to 10%)

-- often a *quick* answer is desirable (at least initially)

-- is a particular effect worth worrying about in detail at all? (don't agonize until you've established it'll be worth it!)

Why estimate?

The idea is generally to concentrate on (and understand) the underlying concepts, rather than the detailed maths. i.e. distill the important bits and filter out the irritating minutiae...

===> ESTIMATION IS PROBABLY MORE IMPORTANT DAY TO DAY THAN DETAILED MATHS!

A rough estimate is pretty much guaranteed to be correct with a factor of 10 (and when it's not, this is usually telling you something important -- e.g. a key physical effect has been ignored!)

Detailed estimates are designed to be highly precise, but are complex enough so it's easy for them to be completely wrong (it's common to get answers to exam question given to 10 decimal places but off by 10 orders of magnitudes!)

GENERAL RULES:

-- Divide and conquer!

-- Guess! Both initially and whenever you need to! Use your gut to check if guesses are sensible.

-- Be an optimist:

-- Assume whatever you need to get going and hope for the best

-- i.e. assume wildly (but not blindly!). e.g. consider a spherical cow...

-- Punt! In a first go, ignore any physical effect that would make life too difficult; related to assume wildly -- just make sure to remember what you've punted on and see if you can/need to return to it later. But the key point is to explore the problem, and if you've got to ignore something that would stop you cold, ignore it (typical example: might ignore air resistance in a problem initially and then see if we can really get away with that)

-- Don't be perfectionist -- lower your standards

-- if you can't solve the whole problem, solve whatever bit of it you can --> you might end up seeing the way to the full solution

-- don't be precise -- the whole point of estimation is to get a rough, but reliable answer, so don't waste your time doing maths to 1% if you've made approximations that are wrong by factors of 10!

-- Cross-check: try getting to the solution in several ways and make sure they agree; use related facts to help you make an estimate (e.g. insurance in van example).

-- Sanity check: Often the point of estimation is to provide a sanity check for a more detailed calculation. But don't forget to sanity check the sanity check - if your rough estimate is out by x1000 from your gut-instinct initial guess, don't blindly assume that your gut was wrong. The beauty of the estimate is that it's so simply that you should be able to see where/why your gut was wrong (*if* it was wrong -- sometimes you'll find you screwed up your estimate, i.e. your gut was right!)

-- Use symbols: freely define symbols for quantities that arise; sometimes even useful to allow for dimensionless fudge factors (e.g. efficiencies) that account for physical effects you've punted on. These can act as convenient reminders that you did punt...

-- Work in symbols until the very end; if you've got to change some parameter in the problem, you don't want to have to repeat tons of algebra, you just want to have a final equation that shows how things depend on the parameter. Also, some things you might think would matter might cancel out (so no point wasting time trying to estimate those things).

-- Make sure you know and keep track of units!

EXAMPLES

How much money is in a Securicor van?
==========

First guess: 1 pound? 10? 100? 1000?
1e9? 1e8? 1e7?

Rubber Tyre
==========

How much rubber is lost each year from the tyres of cars in Southampton?

Maximum Height of Mountains
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What is the maximum height of a mountain on Earth? How about Mars?

Pole Vaulting
==========

How high can a pole vaulter possible jump?

Perfume
=======

How long for perfume to diffuse across room?

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