Patterns of change & hidden graph information 01-03 Notes

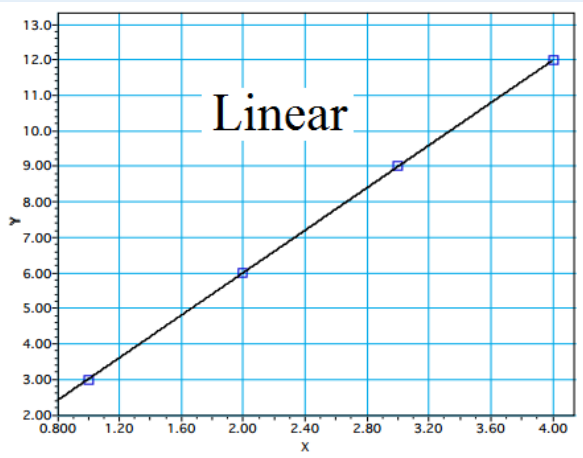
Unit 01, Physics Themed

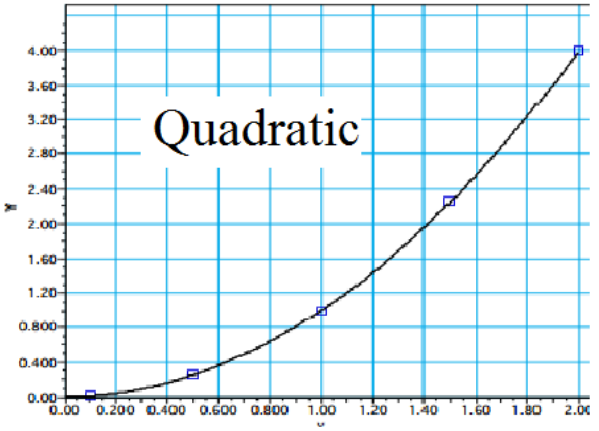
How things change

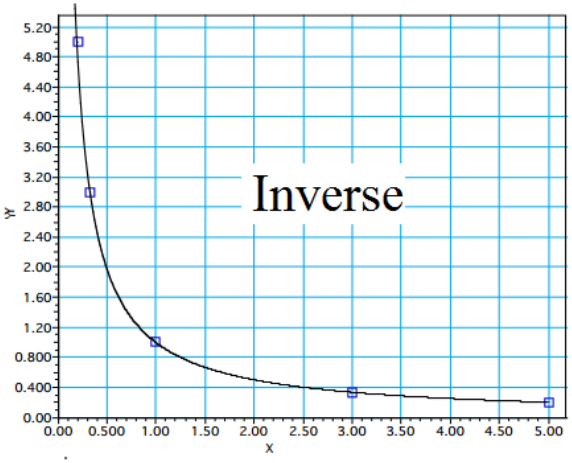
- The further the gas pedal goes down, the faster the car goes
- A change in one thing likely produces a change in something else
- Physics, chemistry, etc. summarizes these predictive relationships with math
- Equations predict values AND how one change will change another, examples:
  - $Y = mx$ → when x doubles, Y consequently doubles too (direct relationship)
  - $Y = m/x$ → when x doubles, Y consequently is halved (inverse relationship)
  - $Y = mx^2$ → when x doubles, Y consequently increases (changes) by 2^2 (quadratic relationship)
  - $Y = m/x^2$ → x increases by factor of 2, y decreases (divides)by a factor of 2^2 (inverse square)

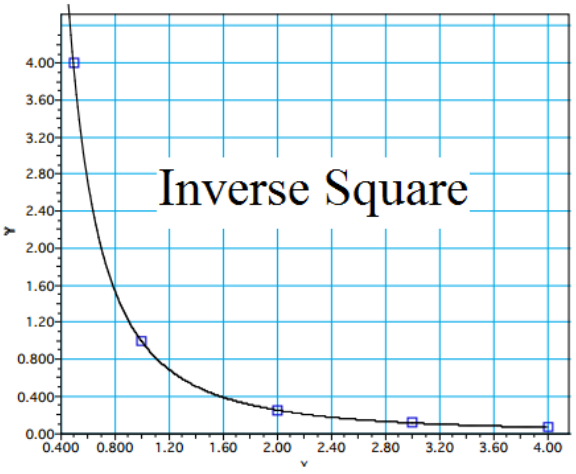
Four relationships – graphical view

- Linear and Quadratic are distinctive shapes
- Inverse and Inverse Square are similar
  - Inverse square approaches asymptotes faster









How things change
Examples

- $X = \frac{1}{2} at^2$: If t changes from 3 seconds to 12 seconds, how much does X change if it's value is 45 m when t = 3 seconds?

Solution: (remember, Δ means change or changes)

- t Δ by 4x (from 3 to 12), but X doesn't change with t, it changes with t^2
- t^2 Δ by 4^2x, or 16x
- X Δ same as t^2 (multiply by 16x)
- New value for X is 45 m x 16 = 720 m

How things change
Examples

- a = F/m: If m changes from 10 kg to 30 kg, how much does a change if it's value is 12 m/s^2 when m = 10 kg?

Solution: (remember, Δ means change or changes)

- m Δ by 3x (from 10 to 30), a changes by same factor (not squared)
- a Δ 3x
- Inverse relationship, so this Δ decreases value (divide by 3)
- New value for a is 12 m/s^2 ÷ 3 = 4 m/s^2

How things change
Examples

- $I = P/4\pi r^2$ or "I Δ inversely with r^2", r represents distance from sound source and I represents sound intensity (kind of like "loudness")
- At 4 m from a sound source, I = 200 W/m^2. If you move from 4 m to 20 m from the sound source, what will the new value for I (intensity) be?

Solution: (remember, Δ means change or changes)

- r Δ by 5x (from 4 to 20), r^2 Δ by $5^2 = 25X$
- I Δ by same factor as r^2 (we decide later on to multiple of divide by this amount)
- Inverse relationship, so this Δ decreases value (divide by 25)
- New value for I is 200 $W/m^2 \div 25 =$ 8 W/m^2

Graph Information
Slopes and Areas

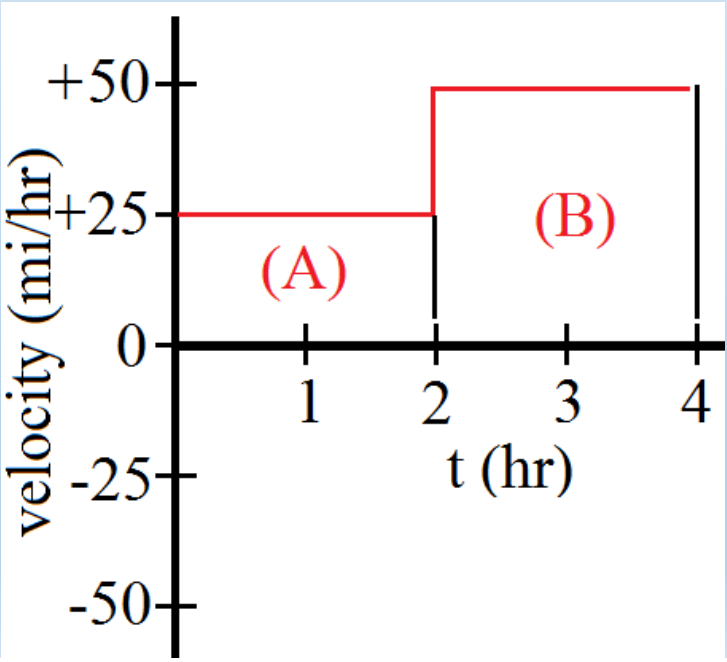
- Three ways to get information from a graph
  - 1st: Read a value directly from a graph (duh), 2nd: from the slope and 3rd: from the "area"
  - Let's learn about the last two!
- Did you know the slope of Y = mX is m?
- The slope represents rise/run, or m = ΔY/ΔX
- Rise just means the Δ vertically, run is the simultaneous horizontal Δ
- See how this might be handy understanding how things change?

Challenge

- P = iV is (power in an electric circuit). Similar to Y = mX?
- For a graph of P vs. V, what would the rise and run be?
- What would the slope be the same as?!?

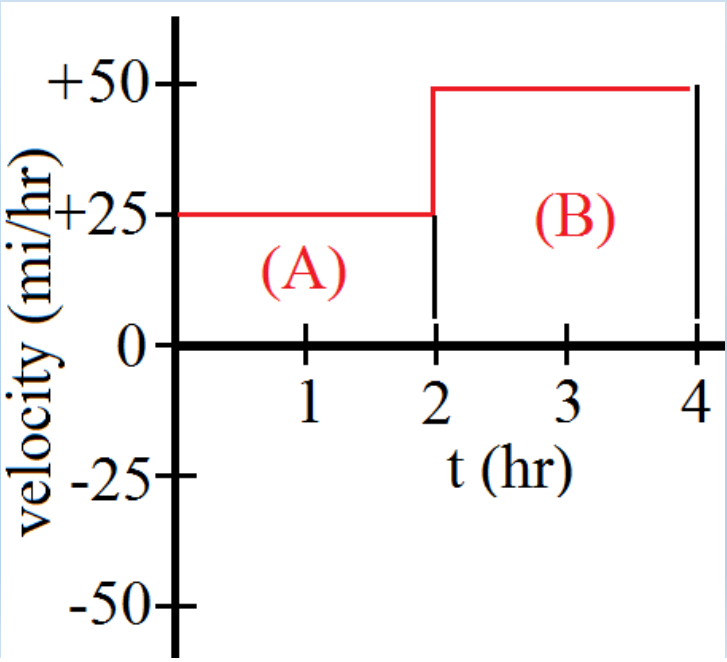
Graph Information - Slopes and Areas

- Slopes are division problems, rise ÷ run
- **New for you**: We can also get information by multiplication too, this is the "area under the curve"
- Area under the curve represent the accumulated positive change, so it's how much area is above zero (horizontal axis)…confusing the 1st time, so look at an example!
- Right: A four hour trip. Two slow hrs & two fast hrs
- You could go back toward home (negative velocity)
- But you only for forward (positive velocity)
- Both areas (A) and (B) represents forward progress:
  - (A): (25 mi/hr) x 2 hr = 50 miles (forward)
  - (B): (50 mi/hr) x 2 hr = 100 miles (forward)
  - Total forward (above zero line) = 50 + 100 = 150 miles!



Graph Information - Slopes and Areas

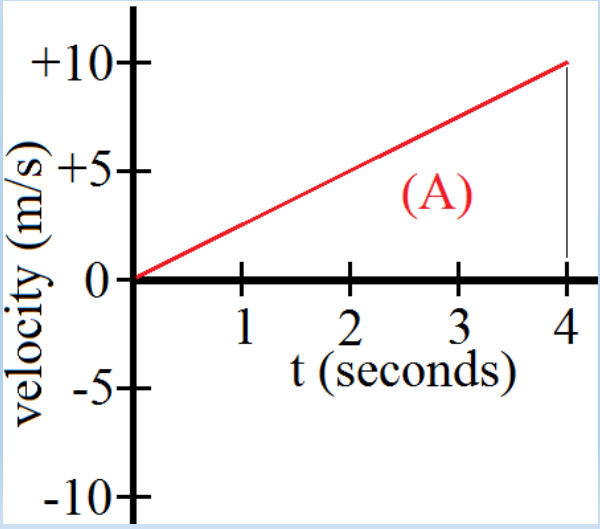
- The equation we used was essentially: how far you go = how fast x how long
- X = V t
- Since “V times t” is like “length times width” you can use the area of a rectangle to represent the amount of “V times t” you have
- The zero axis is a cutoff or forward progress
- Any area accumulated below zero is negative
- Multiplying the units will give you the area’s units:
  - V x t has units mi/hr x hr = miles
  - Miles is correct units for how far you went
  - Being able to multiply units (dimensions) is called:
  - “dimensional analysis”
- **Challenge**: If V = f λ then what graph would:
  - Use slope? Use area? (*graphs of* ____ *vs* ____)



Graph Information - Slopes and Areas

- You may need to find two kind of areas in this class: rectangles and right triangles
- Previous problem was area of a rectangle
- Triangle is where Y-axis value CHANGES
- Example: You speed your car up from 0 to 10 m/s in 4 seconds how far did you go? (how much forward progress did you accumulate?)
- See how the values for velocity CHANGES?
- Each second, more progress accumulates than previous
- Area of triangle captures the varying progress!

A = ½ bh = ½ 4 sec x 10 m/s = 20 m



Solving inverse equations

- A lot of Chemistry and Physics students don't solve inverse equations correctly
- Remember density from chemistry? d = m/v…too often students don't solve for v correctly
- Physics has a lot of inverse equations too
- If you're not confident, try this: divide d by 1, then cross multiply
- You're not required to use this

$$12 = \frac{40}{V} \quad \text{divide by 1} \quad \frac{12}{1} = \frac{40}{V}$$

$$\text{Cross multiply} \quad 12V = 40 * 1 \quad \text{Easy Now} \quad V = \frac{40}{12} = 3.33$$

- Solving inverse equations is required
- Try this: Using E = F/q, find q where E = 7.5 and F = 3.4E-5