HSC PHYSICS

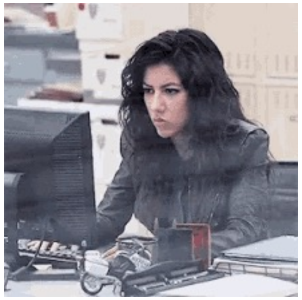
REVISION LECTURE

Presented by:
Angeni Bai

Who Am I?

Hey I'm Angeni! (or call me Genie ☺)

- Graduated last year!
  - 99.80 ATAR
  - State rank 11^{th} in Mathematics (but I like Physics more lol)
- Studying Computer Science as a Co-op Scholar at University of New South Wales
  - Beep boop… $$$
  - I've been producing podcasts too! Check out Echo by CSESoc on Spotify :)
- Things I'm trying to get good at
  - Playing guitar 🤘
  - Cooking 👩‍🍳 – to justify all the Bon Appetit binges
  - Skateboarding 🛹 – my kickflip is coming along…



The Plan!

This is the last stretch, so today we're focusing on filling in any gaps in essential knowledge and *applying* what you already know.

I will also try to prioritise Q+A time over getting through everything in the slides.

The Plan!

Block #1: Syllabus recap

- What was the point of studying Physics?
- Things you might've forgotten (including sneaky Year 11 content)

Block #2: Calculations + short answers

- How to structure calculation questions
- Understanding and deriving, instead of memorising
- Contrary to popular belief, this won't be just Mod 5 + 6!

Block #3: Long responses + last minute revision tips

- How to answer chonky 9 markers :)

SYLLABUS RECAP

Your Exam!

You get:

- 5 minutes reading time
- 3 hours working time

Total marks: 100	**Section I – 20 marks** (pages 2–14) • Attempt Questions 1–20 • Allow about 35 minutes for this section **Section II – 80 marks** (pages 17–36) • Attempt Questions 21–36 • Allow about 2 hours and 25 minutes for this section

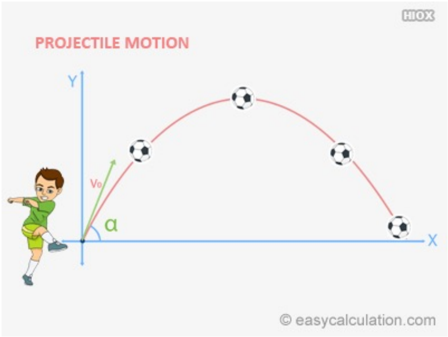
So that's about 1.8 min a mark…

I find it more realistic to allocate

- 1 min per mark in multiple choice (on average)
- 1 min 45 sec per mark in short answers (aka just over 5 min for a 3 marker)
- Leaves 20 min for checking!

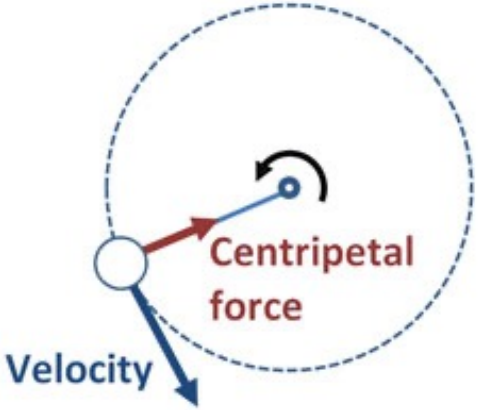
Mod 5 – Advanced Mechanics

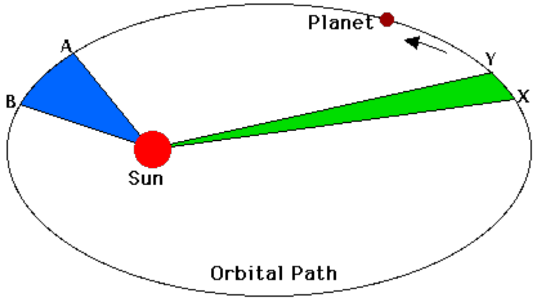
Making stuff move!



How do things move when there's only one force on it?

What about moving in a circle?



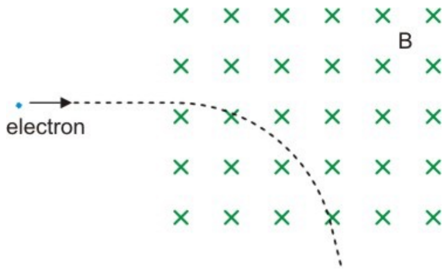


What about in a gravitational field that can change with distance?

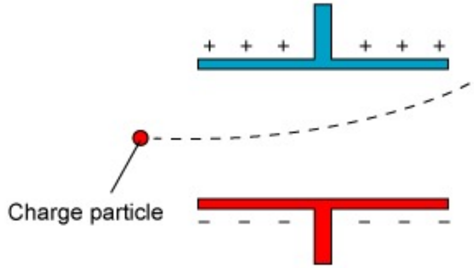
Mod 6 – Electromagnetism

Mod 6 – Electromagnetism

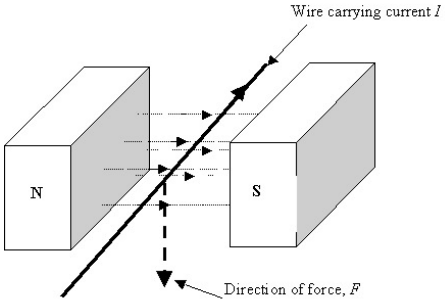
Making stuff move pt2!



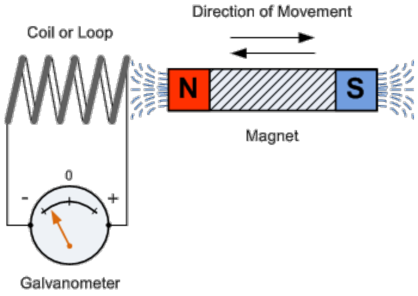
Electric and magnetic fields exert a force on a charge moving through it



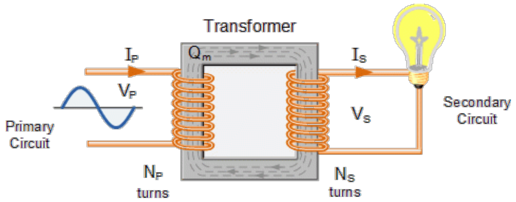
So it makes sense that a magnetic field will exert a force on conductors carrying a current (aka a stream of moving charges)



Changing electric fields and magnetic fields can induce each other

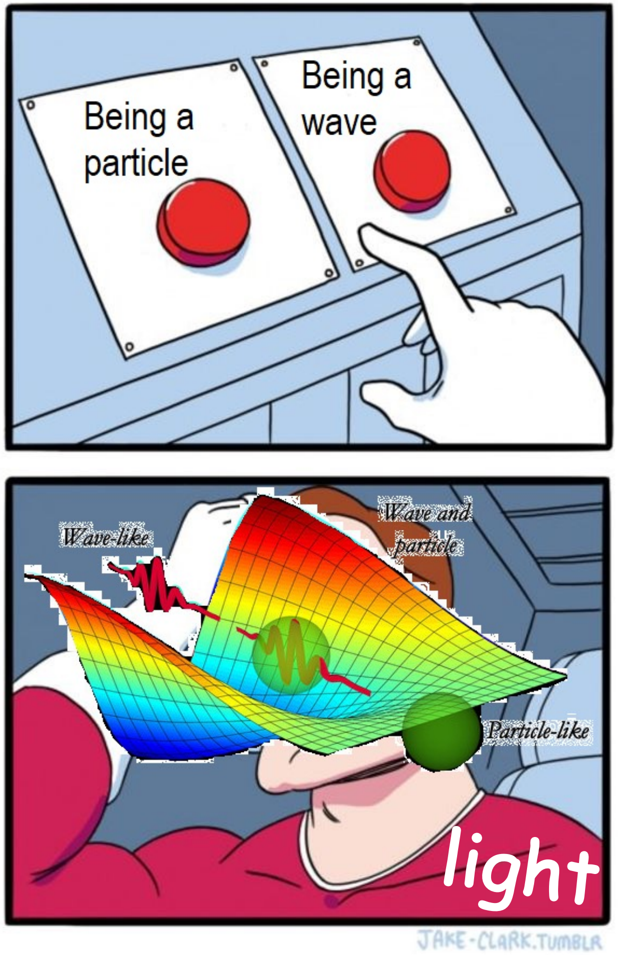


And we apply these properties in various industrial situations



Mod 7 – The Nature of Light

Now here's where things start to get weird…



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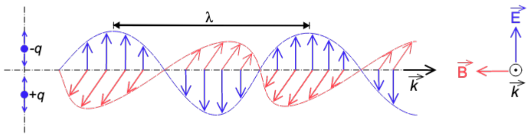
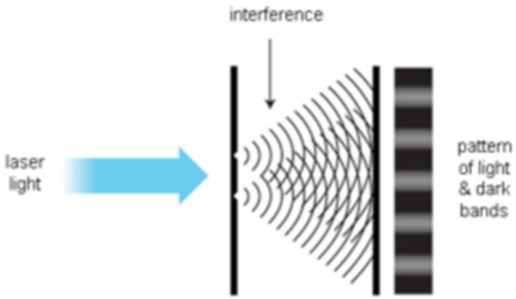
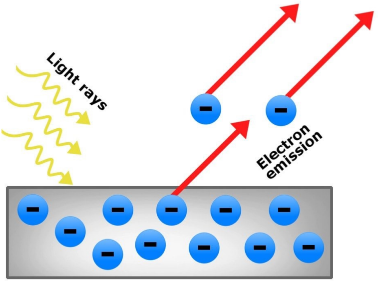


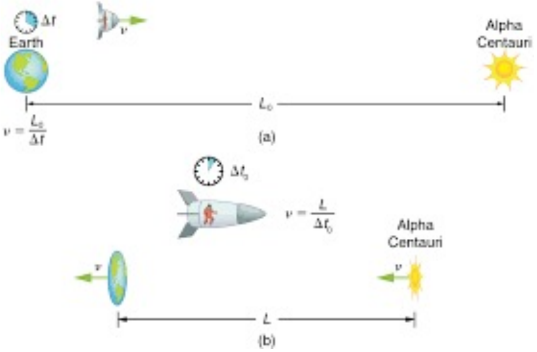
Electricity, magnetism and light are all just different sides of the same electromagnetic coin (thanks Maxwell)



Light is a wave!

But also a particle?

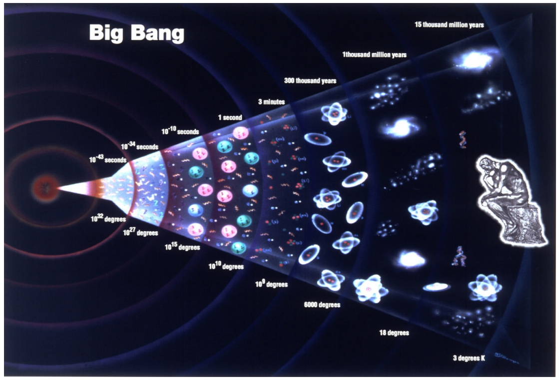




At least we know it behaves the same way wherever we look! But we can't say the same about time and space…

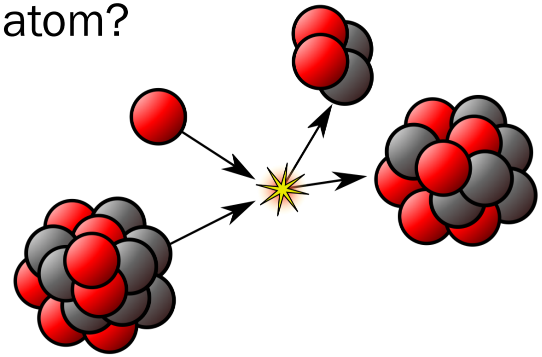
Mod 8 – From the Universe to the Atom

So what do we know about what everything is made up of?
How do we know it… and what don't we know?

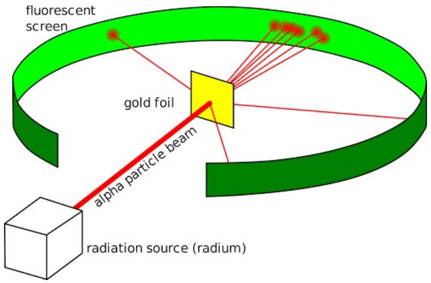


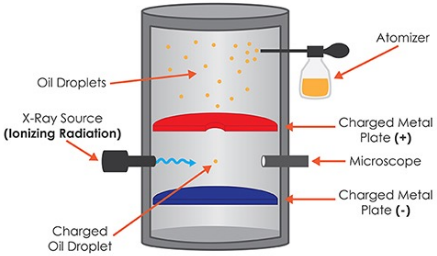
How was everything created?

What weird and mysterious things happen in the atom?



How did we discover what we know about the atom?





So what was the point?

The HSC Physics syllabus is a really great launching point for understanding the mysterious laws that have created the universe we live in.

- Critical analysis of experiments and how theories are revised in response to new evidence
- Applying theory to the physical world
- Hopefully, also shows you how much more there is still to discover!

Units

There will be plenty of unit converting in physics, and no formula sheet to remember all the prefixes. This is the one thing you *need* to know without a doubt.

Prefix	Symbol	Exponent
Nano-	n	10^{-9}
Micro-	μ	10^{-6}
Milli-	m	10^{-3}
Centi-	c	10^{-2}
Kilo-	k	10^{3}
Mega-	M	10^{6}
Giga-	G	10^{9}

Luminosity and Intensity

Luminosity – total energy emitted per unit of time (aka total power emitted)

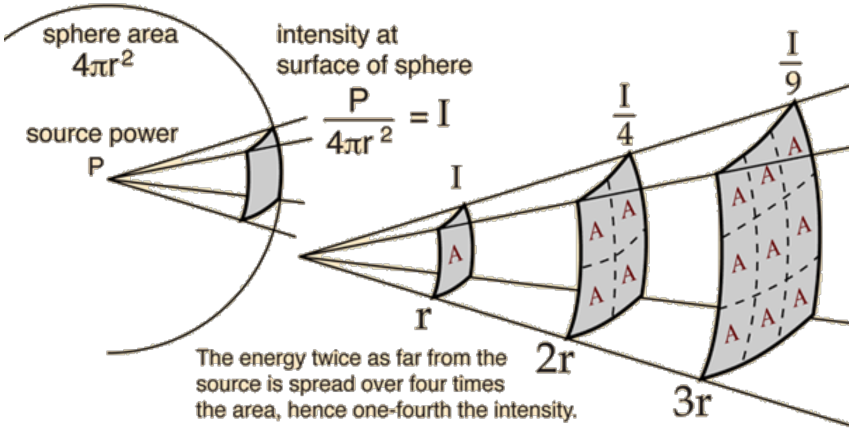
Intensity – the total power transferred per unit of area

- This is *inversely* proportional to distance
- The original luminosity is being spread out over the surface of a sphere

Luminosity

$$I = \frac{L}{4\pi r^2}$$

Surface area of sphere



Luminosity and Intensity

The Sun has a luminosity of 4×10^{26} W. What is its intensity as measured from Earth, if Earth is 150 million km from the Sun?

$L = 4 \times 10^{26}\,W \qquad r = 150 \times 10^6 \times 10^3\,m$

$$I = \frac{L}{4\pi r^2}$$

$$= \frac{4 \times 10^{26}\,W}{4\pi (150 \times 10^9\,m)^2}$$

$$= 1414.710\ldots$$

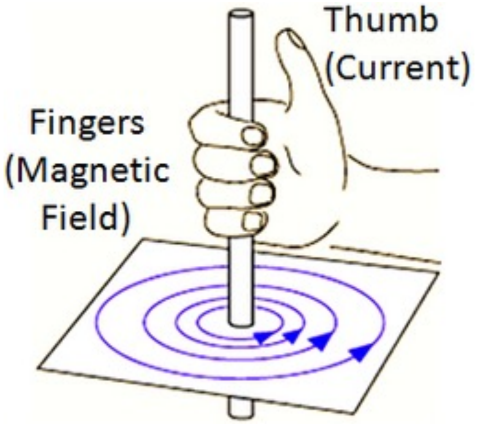
$$= 1.4\,kW/m^2$$

Which Right Hand Rule?

You could *technically* try to apply any of these rules to any electromagnetic situation. But some situations are easier with a particular rule.

Which Right Hand Rule?

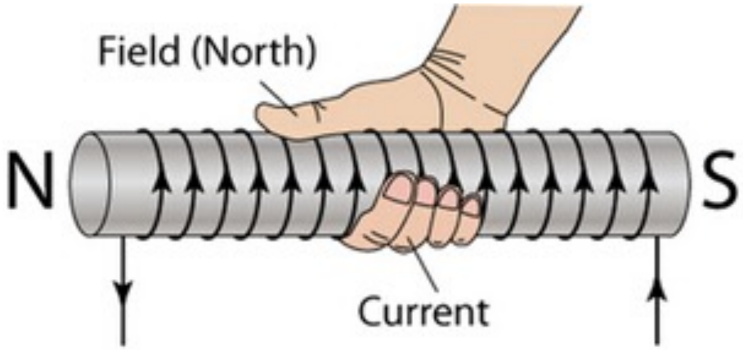
RH Grip Rule

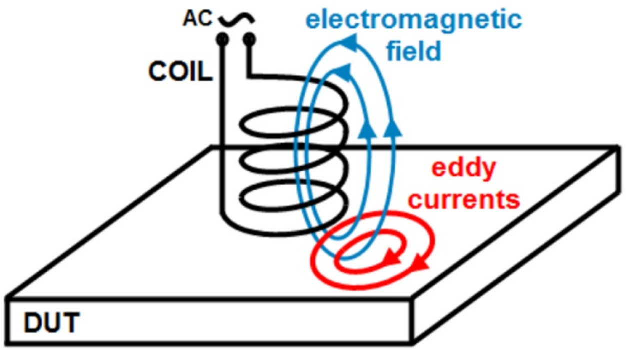


- This one isn't super common in Year 12
- Could be used when figuring out the direction of the force between parallel wires

Which Right Hand Rule?

Another RH Grip Rule

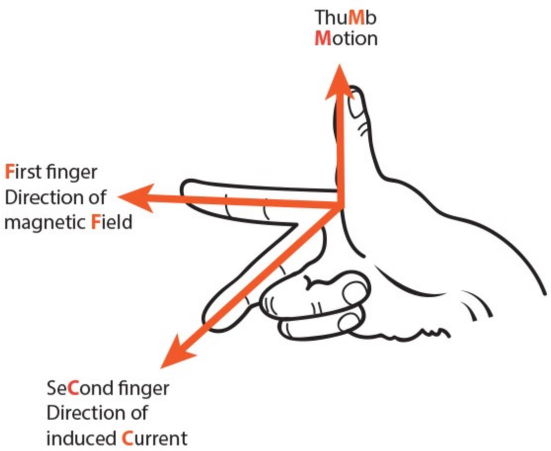


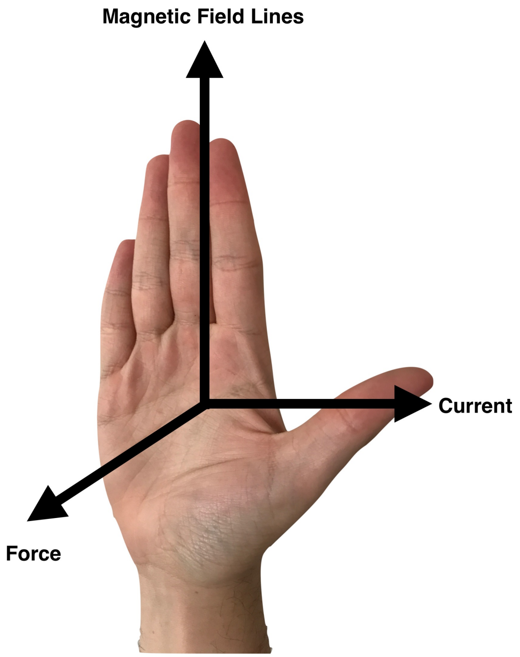


- Solenoids
- Eddy currents

Which Right Hand Rule?

RH Slap Rule/Fleming's RH Rule

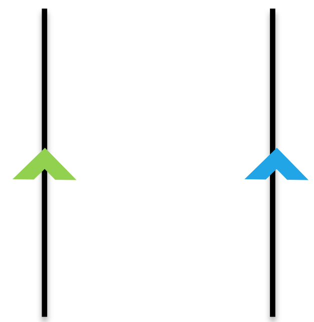




- Charges in a magnetic field
- Motor effect
- Force on a current-carrying conductor

Which Right Hand Rule?

Finding the direction of the force between two wires



Which Right Hand Rule?

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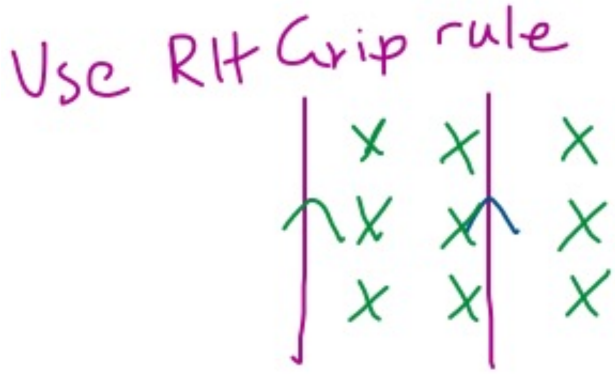
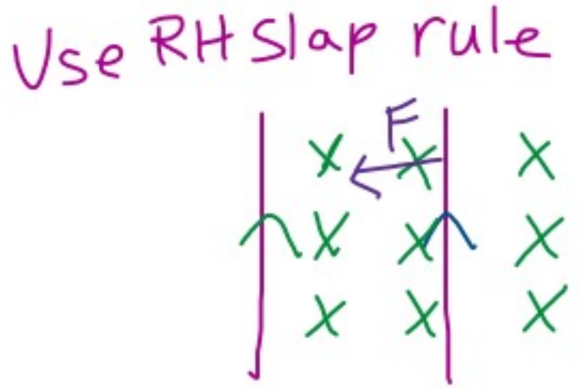


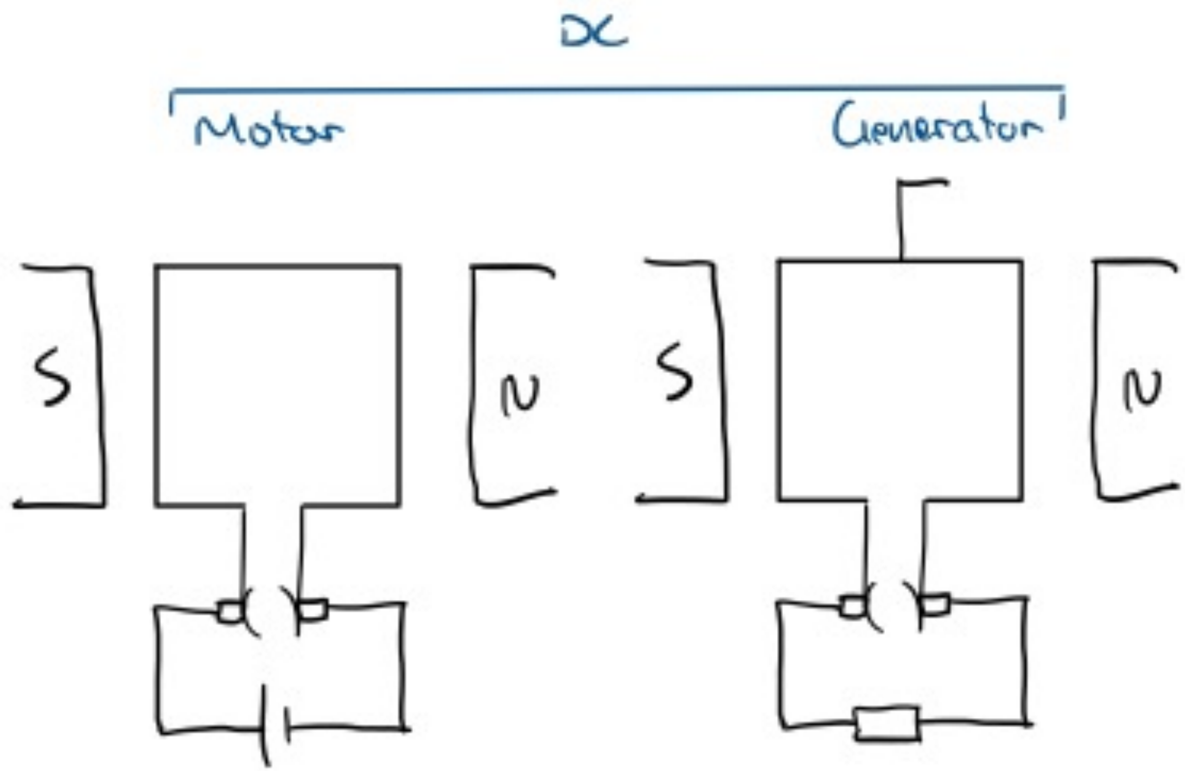


Motors and Generators

The operation of both motors and generators are founded on Lenz's law

Lenz's law *– the direction of the induced emf and resulting current creates a magnetic field that opposes the original change in flux through the circuit.*

Motors and Generators

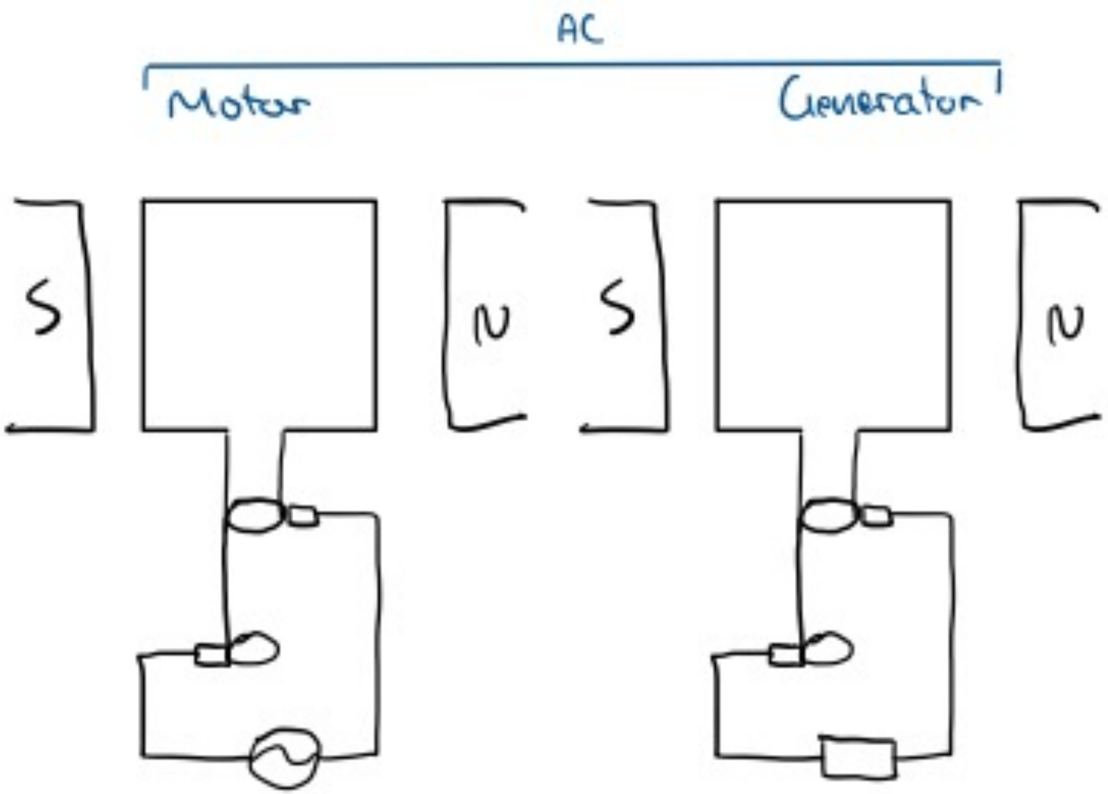


Electrical → mechanical

Mechanical → electrical

Motors and Generators

Disclaimer: the slip rings shouldn't touch



Electrical → mechanical
(AC induction motors are much more common though)

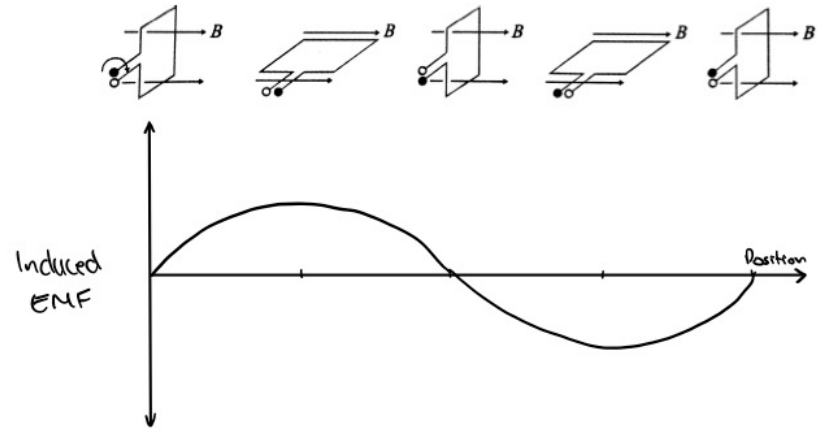
Mechanical → electrical

EMF graphs for GENERATORS

$$\varepsilon = -\Delta\phi / \Delta t$$

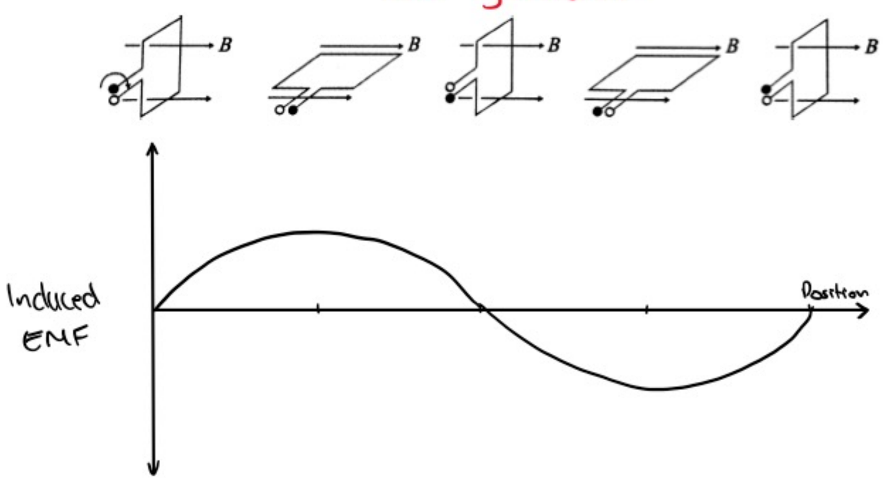
$$= -\Delta BA\cos\Theta / \Delta t$$

In the coil

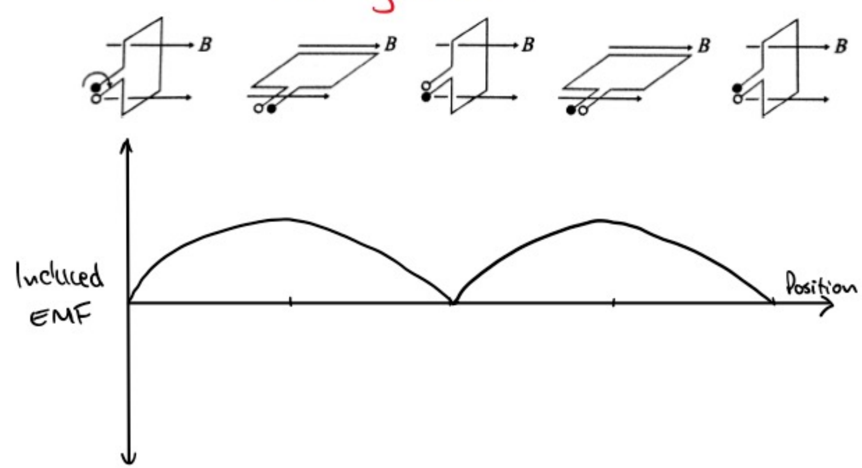


Outside the coil

AC generator

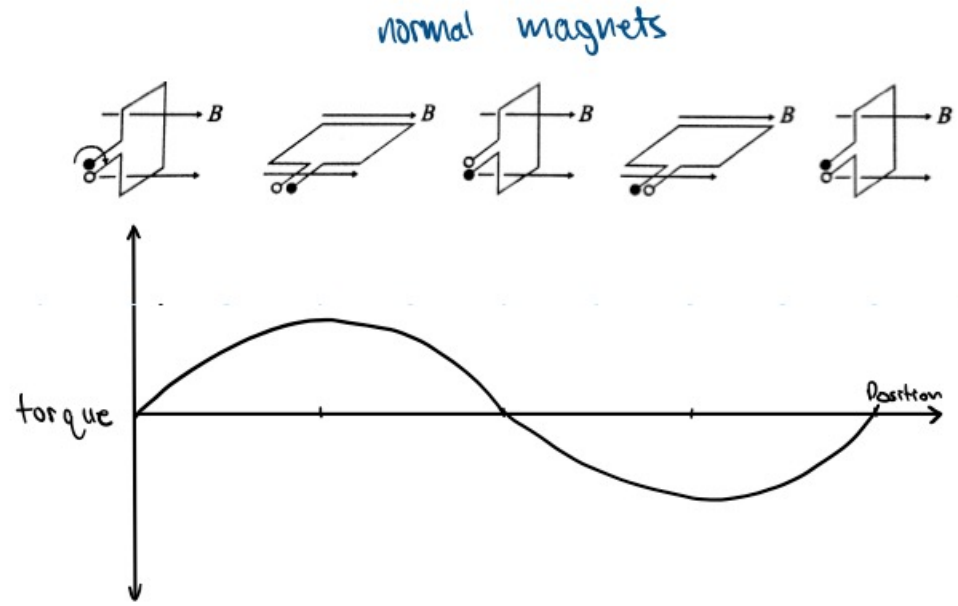


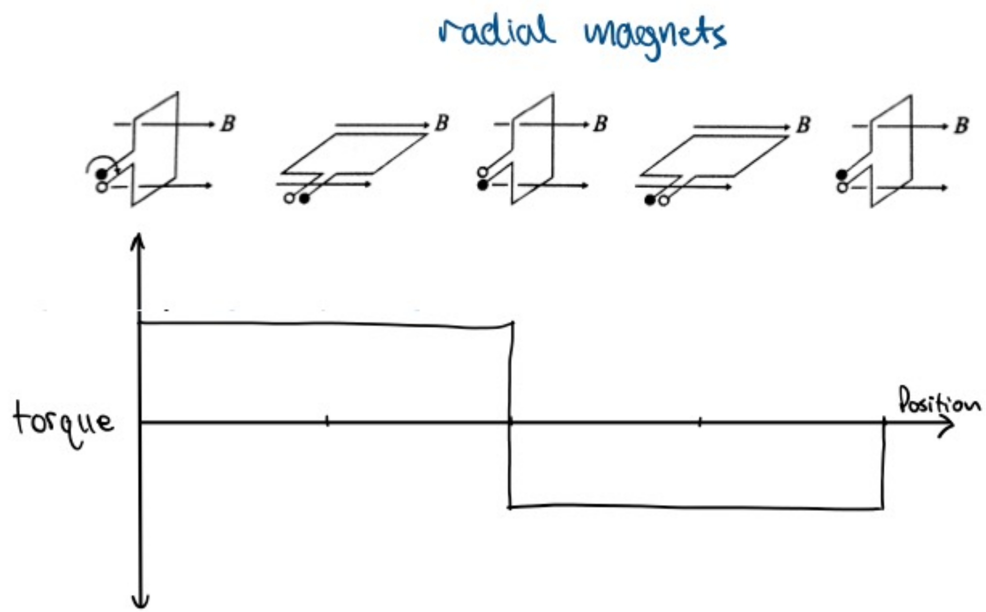
DC generator



Torque graphs for MOTORS

$\tau = nIAB\cos\theta$





Figuring Out the Atom

There's been quite a few improvements to the atomic model over the years!

You should be able to:

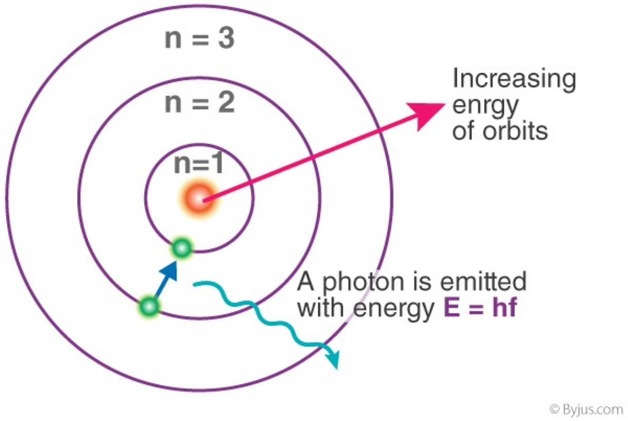
- Identify the key iterations of the atomic model
- Outline the experiments conducted to investigate properties of the atom
- Explain how the results of those experiments led to the development of each model
- Explain the limitations of each model

Figuring Out the Atom

Eg: **Bohr's model**

Key features:

- Electrons in quantized orbits
- Electrons in each orbit possesses a particular energy
- Electrons can absorb energy to excite them to a higher energy level, and release energy to relax to a lower one
- Exact amount of energy must be absorbed or released

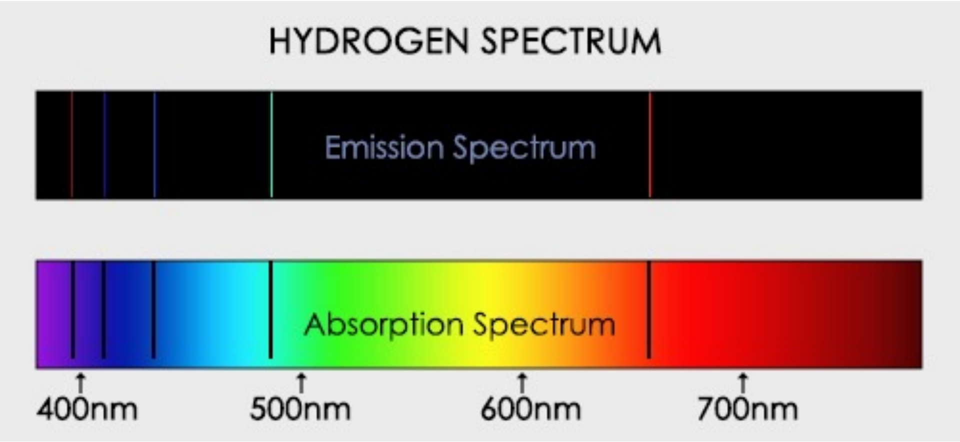


Figuring Out the Atom

Eg: **Bohr's model**

Experimental evidence

- Emission and absorption spectra are produced from elements
- The bands of emission/absorption correspond to the wavelengths of photon energies that are emitted/absorbed
- Bands occur at specific wavelengths – which indicates quantization of the energies



Figuring Out the Atom

Eg: **Bohr's model**

Limitations:

- No reasons were given for the quantized energy levels
- Couldn't explain why the absorption/emission bands sometimes experienced splitting in a magnetic field

Which were addressed in Shrodinger's model later…

Particle Accelerators

It’s kind of in the name – particle accelerators make particles go very fast.

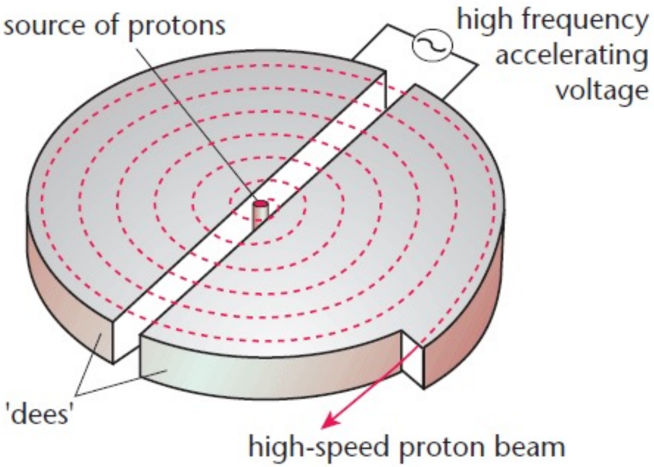
No one really knows how much detail you need to know here, but I think it’s safe to understand **at least:**

- One example of a particle accelerator
- How it’s been used to discover/confirm something in physics

Particle Accelerators

Cyclotron

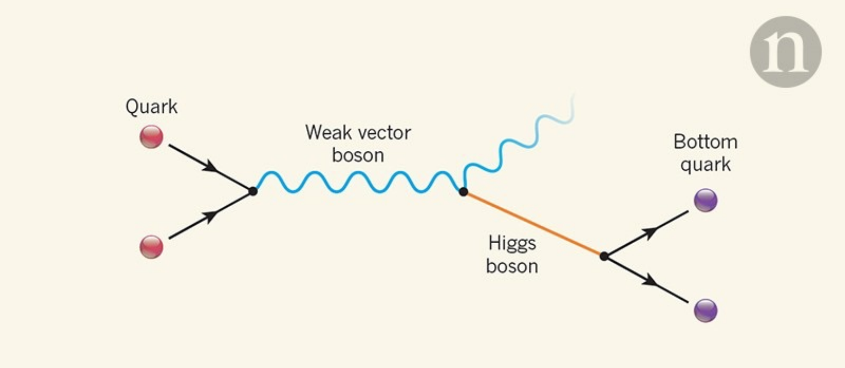
- Accelerates the charged particle back and forth across a gap
  - Occurs because the voltage across the gap is continuously reversing direction
- Results in a circular motion



Particle Accelerators

Discovering the Higgs Boson

- This is a tiny particle that is the reason we have mass
- The Higgs Boson decays into a pair of Z bosons which then decay into two lepton-antilepton pairs



- At higher speeds, particles have greater momentum and energy, meaning their presence can be observed
- So scientists collided protons at high energies (7TeV!), and detected Z bosons and lepton-antilepton pairs

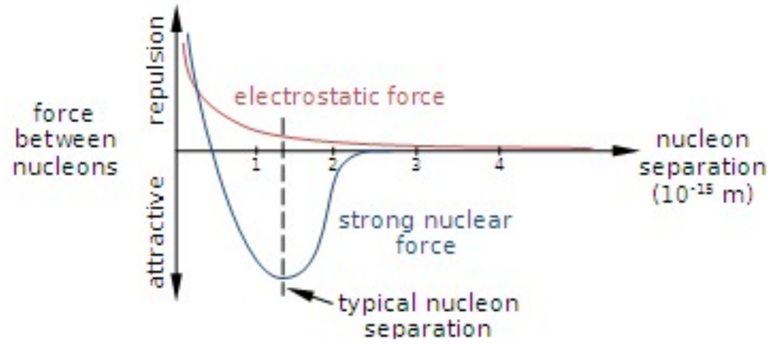
Fundamental Forces

Electromagnetism – attraction/repulsion between charged particles

- Facilitated by the **photon**

Strong nuclear force – attraction between nucleons (but becomes repulsion at very short ranges)

- Facilitated by the **gluon**



Fundamental Forces

Gravity – attraction between objects with mass and/or energy

- Its boson hasn’t been found

Weak nuclear force – attractive force between particles at very very short ranges

- Facilitated by W and Z bosons

Slido Qs

The distance between the Sun and Venus is approximately two-thirds the distance between the Sun and Earth.

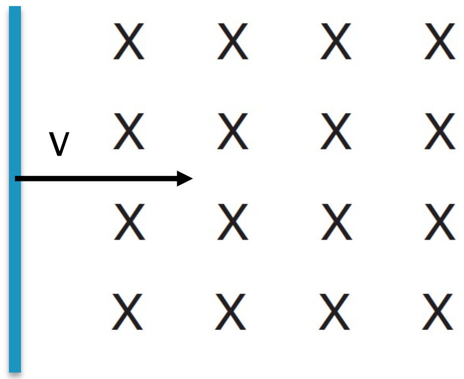
If the intensity of sunlight reaching Earth is I_E, what is the intensity of sunlight reaching Venus?

$I \propto \frac{1}{r^2}$ If $r_V = \frac{2}{3} r_E$ then $I_V = \frac{I_E}{\left(\frac{2}{3}\right)^2}$

$I_V = \frac{9}{4} I_E$

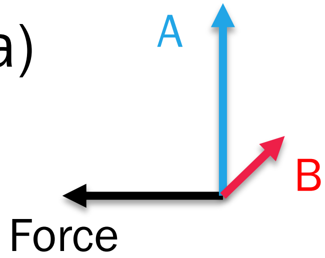
Slido Qs

A metal wire is being moved into the magnetic field as shown.

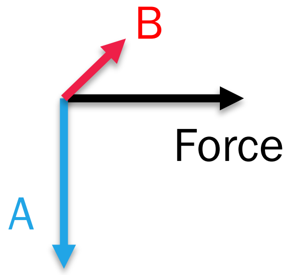


Which of the following show(s) the correct way of using a Right Hand Rule to identify the direction of the induced current in the wire?

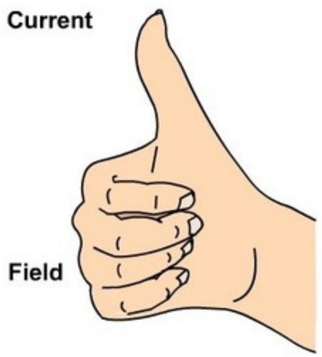
a)



b)



c)



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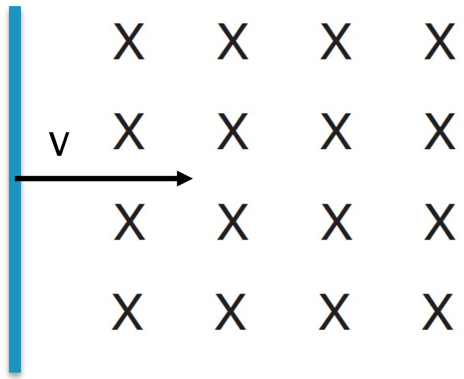

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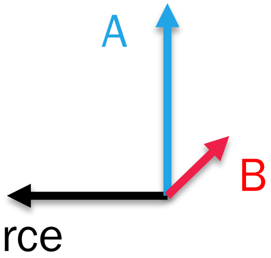
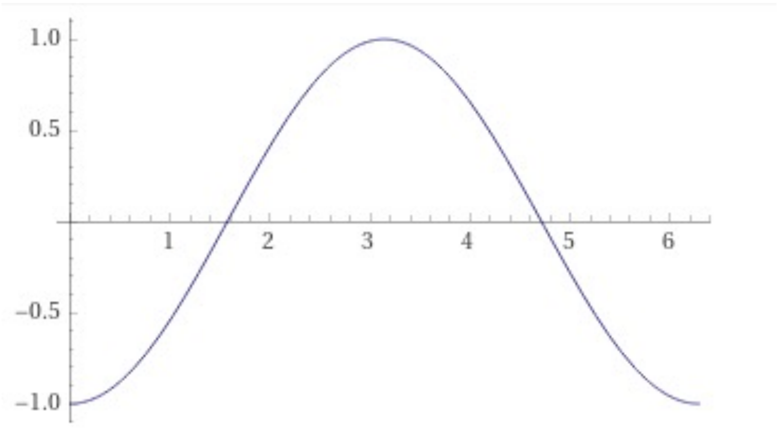


Induced force needs to oppose the change that caused it (ie the movement of wire to the right)

Think about what would happen if the induced force was going the other way?

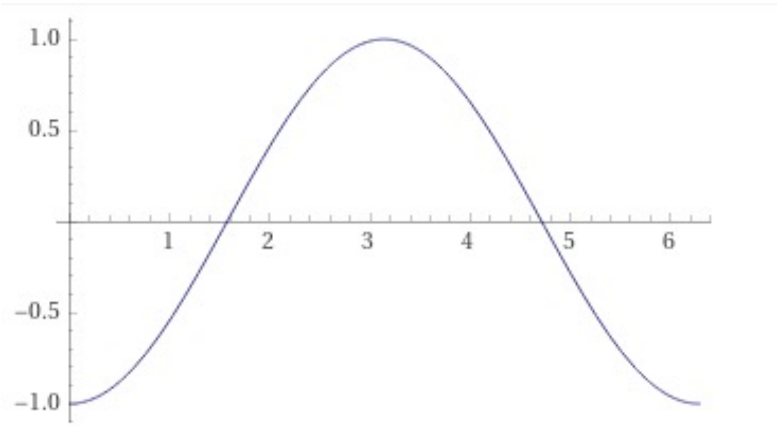
Slido Qs

Some measurements are taken from the operation of an AC generator, which begins with the coil in the horizontal position. One of the measurements produces the following graph for one rotation of the coil at constant speed.



Which measurement(s) could this graph be showing?

Slido Qs



S ——— N

- minimum flux
- maximum emf
- maximum torque

so this graph could be showing emf or torque

CALCULATIONS

Before Memorizing – Understand + Derive!

There is no need to memorise formulas that aren't on the formula sheet. Eg:

- Escape velocity
- Design speed on banked tracks
- Total energy

It's much safer to *understand* the physics principles behind each situation, and be able to derive the formulas yourself.

How to Approach Calculation Qs

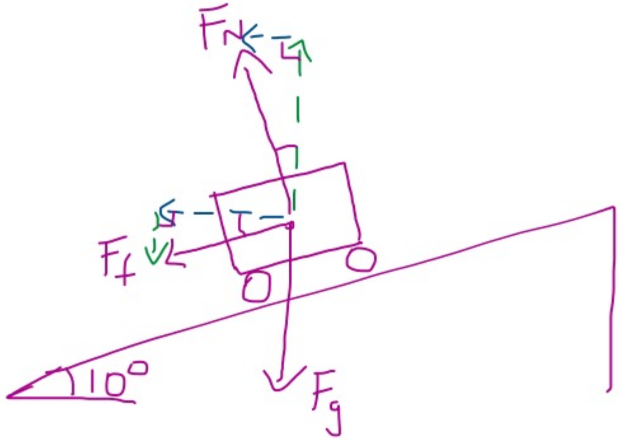
1. Write down all the variables/values you are given (include units!)
2. Draw a **diagram** (if you can)
3. Determine the variable that you need to figure out.
4. Write equations that connect these variables - will you need to combine multiple equations?
5. After calculating: **is this plausible**?
    1. Energy changes - is the sign believable
    2. Magnitude - does it seem consistent with other values

Now let’s try an apply these ideas!

Jacaranda Physics - 2.3

A car of mass 1280kg travels around a bend with a radius of 12.0m. The total sideways friction on the wheels is 16 400N.

Calculate the maximum constant speed at which the car can be driven around the bend without skidding off the road if the road is banked at an angle of 10º. **(3 marks)**



For maximum constant speed, the frictional force acts down the ramp

Jacaranda Physics - 2.3

On a banked track, the net force is the centripetal force acting in horizontal direction towards centre of circular motion.

Vertical direction: net force is zero

$$F_g + F_f \sin 10^\circ = F_N \cos 10^\circ$$

Horizontal direction: net force is centripetal force

$$F_f \cos 10^\circ + F_N \sin 10^\circ = F_c$$

Jacaranda Physics - 2.3

$$F_g = mg$$
$$= 1280kg \times 9.8ms^{-2}$$
$$= 12544N$$

$$F_f = 16400N$$

$$F_c = \frac{mv^2}{r}$$
$$= \frac{1280v^2}{12}$$
$$= \frac{320}{3}v^2$$

$$F_N = \frac{F_c - F_f\cos 10^\circ}{\sin 10^\circ}$$

$$F_N = \frac{F_g + F_f\sin 10^\circ}{\cos 10^\circ}$$

Jacaranda Physics - 2.3

$$\frac{F_c - F_f \cos 10^\circ}{\sin 10^\circ} = \frac{F_g + F_f \sin 10^\circ}{\cos 10^\circ}$$

$$F_c = \frac{\sin 10^\circ (12544 + 16400 \sin 10^\circ)}{\cos 10^\circ} + 16400 \cos 10^\circ$$

$$\frac{mv^2}{r} = 18864.842\ldots$$

$$v = \sqrt{\frac{12 \times 18864.84\ldots}{1280}}$$

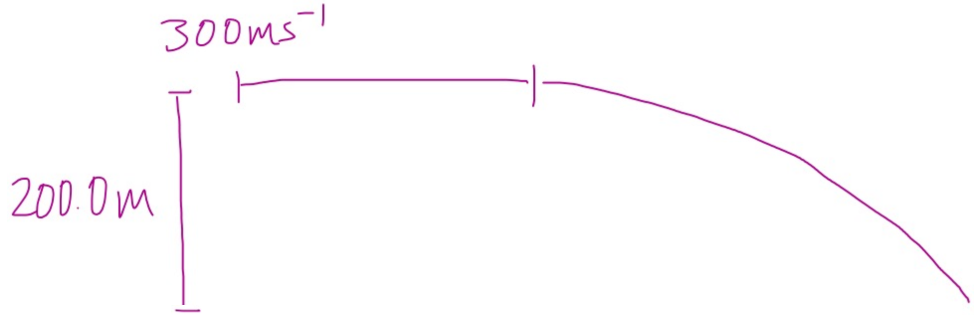
$$= 13.2987\ldots$$

$$= \underline{\underline{13.3\,ms^{-1}}}$$

PEM Trial 2019 – Q25

Maverick's F18 plane is flying at a constant altitude of 200.0m and a speed of 300.0ms^{-1} . His rockets accelerate at 25.0ms^{-2} for 10.0 seconds in a straight line until the fuel runs out. At this point the missiles follow normal projectile motion and cruise down to the surface.

Determine the distance from his target that Maverick should fire his missile in order to hit it. (3 marks)



PEM Trial 2019 – Q25

Part 1

	H
s	?
u	300
v	?
a	25
t	10

Horizontal:

$$v = u + at$$
$$= 300 + 25(10)$$
$$= 550\ ms^{-1}$$

$$s = ut + \frac{1}{2}at^2$$
$$= 300(10) + \frac{1}{2}(25)(10)^2 = 4250\ m$$

PEM Trial 2019 – Q25

Part 2

	H	V
s	?	-200
u	550	0
v	?	?
a	0	-9.8
t	?	?

Vertical

$$s = ut + \frac{1}{2}at^2$$

$$-200 = -\frac{1}{2}(9.8)t^2$$

$$t = \sqrt{\frac{400}{9.8}}$$

$$= 6.3887\ldots \text{ s}$$

Horizontal:

$$s = ut + \frac{1}{2}at^2$$

$$= 550(6.38\ldots)$$

$$= 3513.82\ldots$$

Total horizontal $s = 4250 + 3513.8\ldots$

$$= 7763.82\ldots$$

$$= 7764 \text{ m}$$

NEAP Trial 2019 – Q24

Distinguish between escape velocity and orbital velocity. Include the formulae for both velocities in your answer. (4 marks)

Escape velocity: velocity required to completely escape the influence of a body's gravitational field

Orbital velocity: velocity required to remain in orbital motion around a body

NEAP Trial 2019 – Q24

Escape velocity formula:

Total energy after escaping $\vec{g}$ field = 0 so

$$\frac{1}{2}mv^2 - \frac{GMm}{r} = 0$$

$$\frac{1}{2}mv^2 = \frac{GMm}{r}$$

$$v = \sqrt{\frac{2GM}{r}}$$

NEAP Trial 2019 – Q24

Orbital velocity formula:

$F_c = F_g$ ← In orbital motion, centripetal force is equivalent to gravitational force

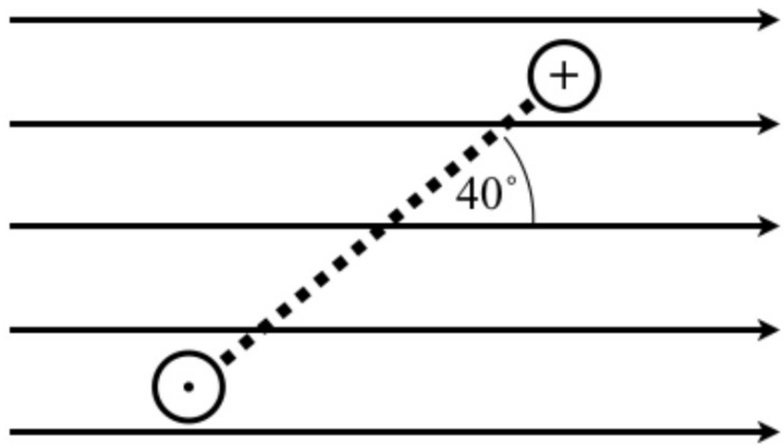
$$\frac{mv^2}{r} = \frac{GMm}{r^2}$$

$$v = \sqrt{\frac{GM}{r}}$$

PEM Trial 2019 – Q30

The cross section of a coil in a magnetic field is shown. The square coil of side length 12.00cm has 8 turns, and a current of 3.00A. The magnetic field has a strength of 2.50×10^4T.

What is the magnitude and direction of the torque on the coil when it is in the position shown below? **(3 marks)**



What's Theta?

It gets confusing to remember which angle theta refers to in each of these equations.

$$F = qv_{\perp}B = qvB\sin\theta$$

Force on charge in magnetic field

$$F = lI_{\perp}B = lIB\sin\theta$$

Force on current-carrying conductor in magnetic field

$$\Phi = B_{||}A = BA\cos\theta$$

Flux through an area

$$\tau = nIA_{\perp}B = nIAB\sin\theta$$

Torque on a coil

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Torque on a coil

So we can pay attention to these instead!

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Flux through an area

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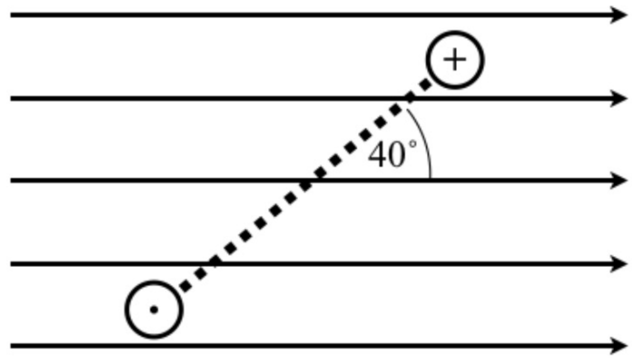
Torque on a coil

So we can pay attention to these instead!

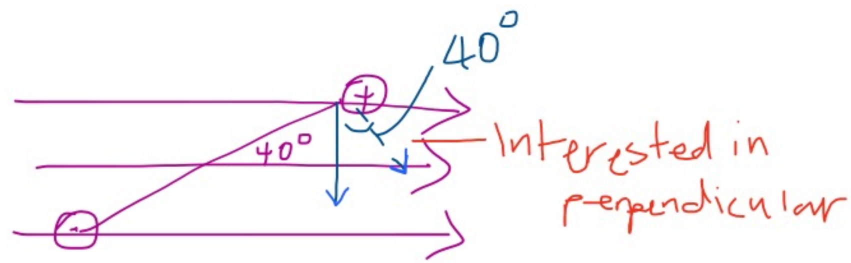
OR

Think about when the value is at a maximum or minimum.

PEM Trial 2019 – Q30



$\tau = BAIn$



$= 2.5 \times 10^{4} \times (0.12)^{2} \times 3 \times 8 \times \cos 40^{\circ}$

$= 6618.6239\ldots$

$= 6620\,\text{Nm}$ clockwise

Jacaranda Physics – Q29

The nearest star (apart from the Sun) is 4.2 light-years from a spacecraft travelling towards it at 0.7c.

a) How far is it to that star according to the astronauts on that spacecraft?

b) How long would it take to get there in the spacecraft?

c) How long will the journey take, based on measurements from Earth? (Assume that Earth is stationary relative to the star)

Special Relativity

Special relativity questions come down to one thing: **identifying the proper time/length/mass**

Proper time/length/mass – the value as measured in the frame of reference stationary to the object of interest

Jacaranda Physics – Q29

a) 4.2 light years away, from outside perspective

From astronaut perspective:

$$L = L_0 \sqrt{1 - \frac{v^2}{c^2}}$$

contracted length

$$= 4.2\sqrt{1 - 0.7^2}$$

$$= 2.999\ldots \text{ light years}$$

Jacaranda Physics – Q29

b) $t = \frac{d}{s}$

$= \frac{2.99\ldots \text{ lightyears}}{0.7 \text{ lightspeed}}$

$= 4.2848\ldots$

$= 4.3 \text{ years}$

Jacaranda Physics – Q29

c) $t = \frac{4.2 \text{ light years}}{0.7 \text{ lightspeed}}$

$= 6 \text{ years}$

ALSO

$t = \frac{t_0}{\sqrt{1 - \frac{v^2}{c^2}}}$

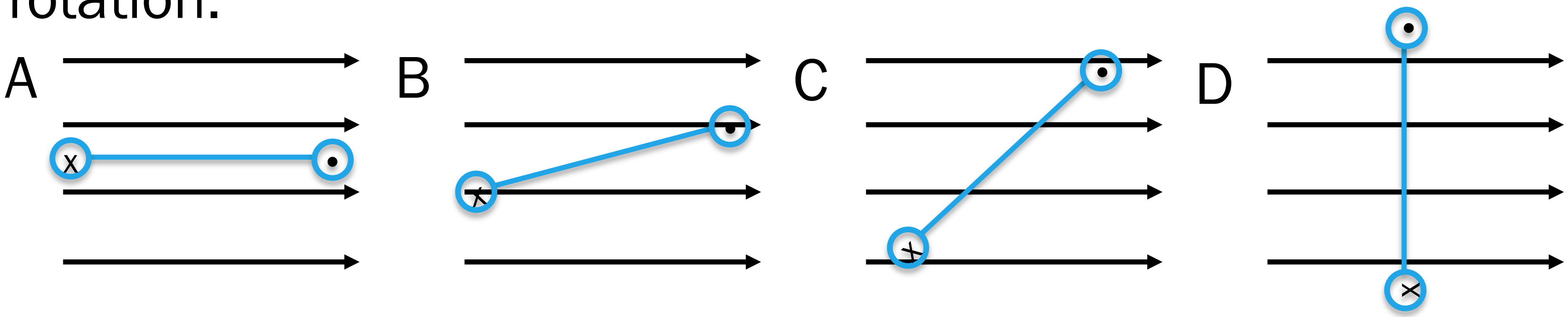
$= \frac{4.3}{\sqrt{1 - 0.7^2}}$

$= 6.0212\ldots$

$= 6 \text{ years}$

Slido Qs

The positions of the coil in a DC motor is shown over one rotation.



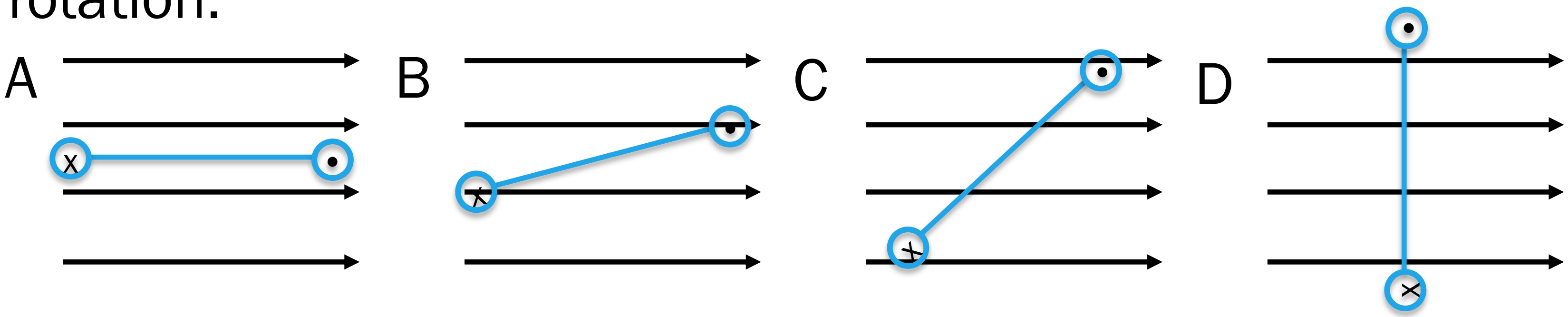
*At which position is the magnetic flux through this coil at a **minimum?***

*At which position is the torque on this coil at a **minimum**?*

*At which position is the torque on this coil at a **maximum?***

Slido Qs

The positions of the coil in a DC motor is shown over one rotation.



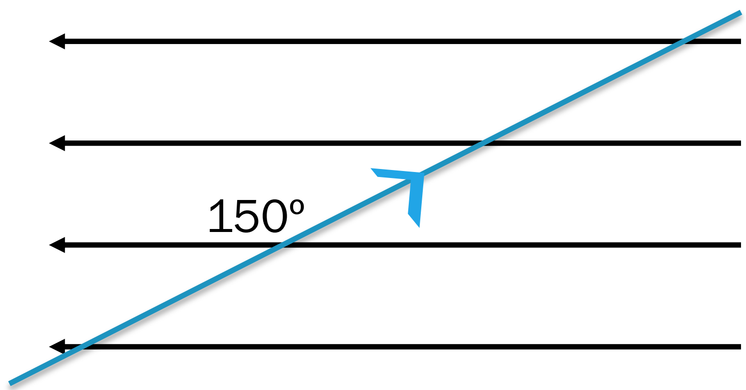
ϕ at max at A

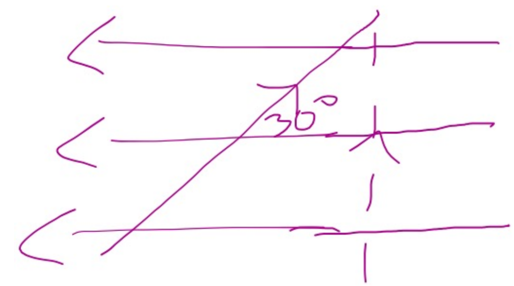
τ at min at D

τ at max at A

Slido Qs

Which equation(s) can be used to calculate the magnitude of the force on this current-carrying wire?





a) $F = 0.5\ \text{T} \times 2\ \text{A} \times 0.1\ \text{m} \times \sin(90^\circ)$

b) $F = 0.5\ \text{T} \times 2\ \text{A} \times 0.1\ \text{m} \times \sin(60^\circ)$

c) $F = 0.5\ \text{T} \times 2\ \text{A} \times 0.1\ \text{m} \times \sin(30^\circ)$

d) $F = 0$

$F = BILn$

$= BILn \sin 30^\circ$

Slido Qs

Muons are formed 9km above the Earth's surface and travel towards the Earth at a speed of 0.998c. A stationary muon has an average lifespan of 2.2 microseconds.

What is the proper length of the distance travelled by the muons?

$L_0 = 9\text{km}$ (From Earth perspective)

What is the proper time of the muons' lifespan?

$t_0 = 2.2\sqrt{1-0.998^2}$ (from Muon's perspective)

LONG RESPONSES

How To Answer Big Questions

The hard part about bigger questions is that there's a *lot* to cover. So how do you communicate everything you need to in a logical and structured way?

MAKE A PLAN

Making a plan will help you:

- Break a big question down into manageable sub-questions
- Feel confident about what you need to cover in your response
- Give your long response some structure, which is easy to follow for a marker

Planning a Response

1. **Intro** – having an introducing sentence is nice, but not 100% necessary for a good mark
2. **Define** key terms and concepts – show the marker that you know the basics!
3. **Break down** the question – if this question had parts a), b), c), etc, what would they be?
4. **Gather evidence** – are there any equations you need to discuss?

Independent Trial 2019 - Q31

Compare the models of light that were proposed by Newton and Huygens and analyse the experimental evidence that supported the models at the time. **(7 marks)**

Slido Qs

Which model of light was proposed by Newton?

Which model of light was proposed by Huygens?

Tick the experimental evidence which supported the wave model of light.

Tick the experimental evidence which supported the corpuscular model of light.

Exam Choice Trial 2019 - Q30

Analysis of the spectrum of a star can reveal information about the star, including its surface temperature, rotational and translational velocity, density and chemical composition.

Discuss how our understanding of the production of a star's spectrum and the features they contain has allowed astronomers to reveal this information. (9 marks)

Slido Qs

Which feature of a star's spectrum could provide information about its…

a) *Temperature?*
b) *Rotational velocity?*
c) *Translational velocity?*
d) *Chemical composition?*

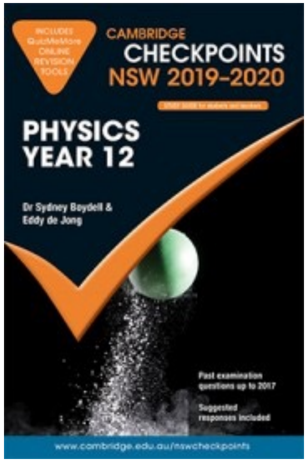
I will also talk about density…

How To Study???

I encourage you all to find out what study strategies work for *you*, but these are some things that I found helpful in Year 12!

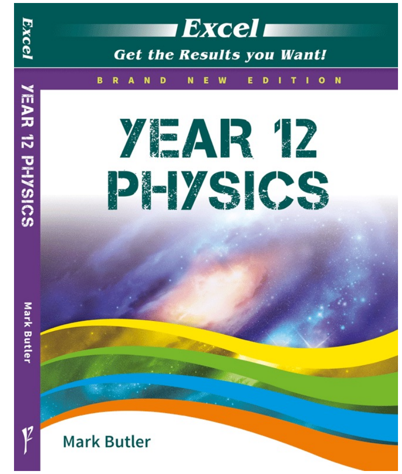
- Go through the whole syllabus and mark your level of confidence with each topic. You could also come up with HSC-style questions to test each dot point.
- Derive every formula on the formula sheet
- Explain concepts to family members/friends/pets
- Make a plan – make each day realistic
- Go for walks!

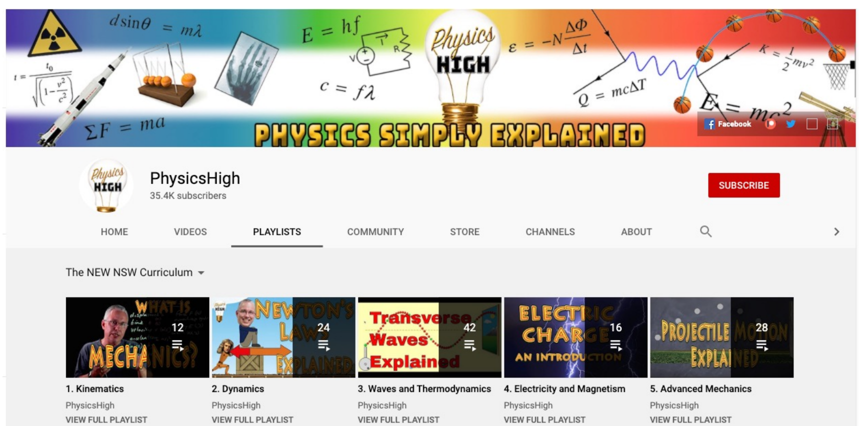
Other Great Resources!



Cambridge Checkpoints NSW 2019-2020

Excel Year 12 Physics





[PhysicsHigh Youtube Channel]

Great work everyone!

Now go have some fun with physics ☺