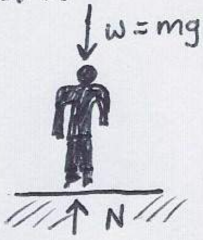
1. Do astronauts on the International Space Station experience zero gravity? Explain the difference between weightlessness and apparent weightlessness.

Weight technically means "the force that two bodies exert on each other due to gravity".



$$W = mg = \frac{GmM}{r^2}$$

On the International Space Station, the Earth still exerts a gravitational force on the astronauts so they are not weightless. However, the ISS is orbiting the Earth meaning that astronauts feel as though they are in constant free fall because there is no normal force pushing on them from below. This is called apparent weightlesness.

2. Craig Lowndes, a V8 Supercar driver accelerates at 35 m/s^2 off the start line. How many g-forces does he experience?

The formula for g-force is :

$$g\text{ force} = \frac{a+g}{g} \quad \text{OR equivalently} \quad g\text{ force} = 1 + \frac{a}{g}$$

where $g = 9.8\ m/s^2$.

Therefore:

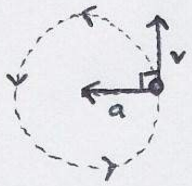
$$g\text{-force} = \frac{35 + 9.8}{9.8} = \boxed{4.6\ g\text{'s}} \quad (2\text{ sig figs})$$

3. At the market, a butcher tells you a certain steaks weight is 1kg. Explain why this is not technically correct.

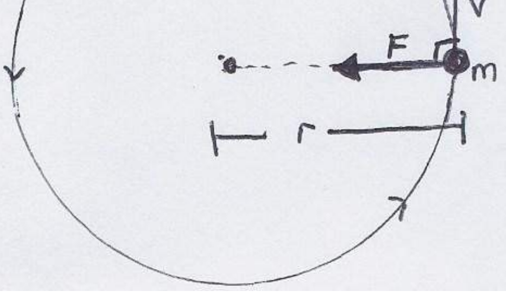
Weight is technically a force. It is the force that the Earth exerts on the steak ($w = mg = 1 \times 9.8 = 9.8\,N$). The Butcher gave you the mass of the steak (1kg), not the weight (9.8 N).

4. Define the terms Uniform Circular Motion and Centripetal Force.

Uniform Circular Motion: The motion of an object moving in a circle with constant speed. Despite having constant speed, the object is continually accelerating as it's velocity (speed in a given direction) is always changing. This acceleration is provided by a centripetal force which always points towards the centre of the circle (at 90° to the objects velocity).



Centripetal Force:

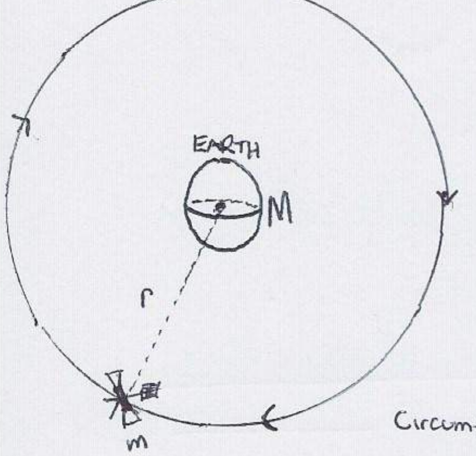


A force directed at right angles to a particles velocity. It can be provided by a range of mechanisms including gravity, tension on a string, magretism, etc. The magnitude of the force is:

$$F_{centripetal} = \frac{mv^2}{r}$$

5. By equating Newton's Law of Gravitation with the expression for Centripetal Force, derive the formula for the time that a satellite takes to orbit a body in terms of M, the mass of the large body, and r, the distance between the satellite and the body.

$F_{GRAVITY} = \frac{GMm}{r^2}$ and $F_{centripetal} = \frac{mv^2}{r}$



Equating the two:

$$\frac{GM\cancel{m}}{r^2} = \frac{\cancel{m}v^2}{r}$$

$$\frac{GM}{r} = v^2 \text{ .... } (*)$$

Speed is distance over time so:

Circumference → $v = \frac{2\pi r}{t} \Rightarrow v^2 = \frac{4\pi^2 r^2}{t^2}$ (squaring both sides)

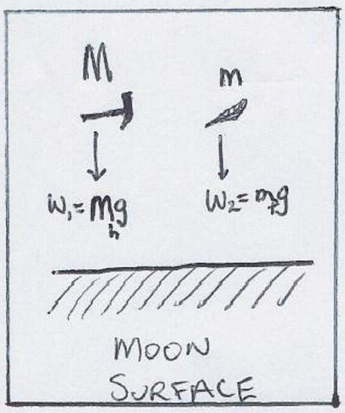
Substitute this v^2 into (*):

$$\frac{GM}{r} = \frac{4\pi^2 r^2}{t^2} \Rightarrow t^2 = \frac{4\pi^2 r^3}{GM} \Rightarrow \boxed{t = 2\pi\sqrt{\frac{r^3}{GM}}}$$

6. In 1971, Apollo 15 astronaut David Scott dropped a feather and a hammer from the same height whilst on the moon. Both hit the ground at the same time. With reference to Newton's Law of Universal Gravitation, identify why both objects accelerate at the same rate?

Newton's Law of Universal Gravitation says that the hammer and the feather experience a force given by:

$$F_{hammer} = \frac{GM_h M_{moon}}{r^2} \quad \text{AND} \quad F_{feather} = \frac{GM_f M_{moon}}{r^2}$$



f = feather
h = hammer

From Newton's Second Law:

$$F_{hammer} = m_{hammer} a_h \quad \text{AND} \quad F_{feather} = m_{feather} a_f$$

Equating the expressions for Force:

MASS OF OBJECT CANCEL ⟶ $\cancel{m_h} a_h = \frac{G\cancel{m_h} M_{moon}}{r^2}$ $\quad \cancel{m_f} a_f = \frac{G\cancel{m_f} M_{moon}}{r^2}$

$$\boxed{a_h = \frac{GM_{moon}}{r^2}} \longleftarrow \text{SAME ACCELERATION} \longrightarrow \boxed{a_f = \frac{GM_{moon}}{r^2}}$$

7. Does both the hammer and the feather experience the same force?

No.

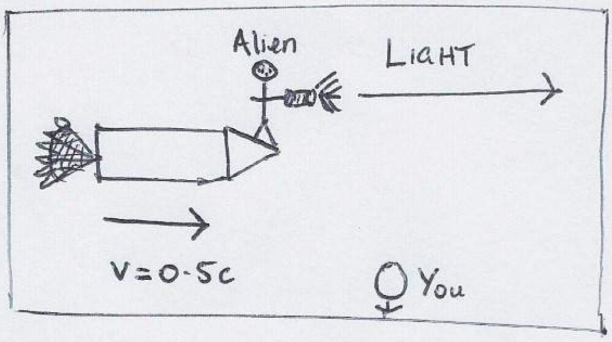
$$F_{hammer} = m_{hammer}\, g = m_{hammer} \left(\frac{GM_{moon}}{r^2} \right)$$

↑ different ↓ ↑ different ↙

$$F_{feather} = m_{feather}\, g = m_{feather} \left(\frac{GM_{moon}}{r^2} \right)$$

Since m_{hammer} is bigger than $m_{feather}$, the hammer will experience a bigger force. So they experience different forces but accelerate at the same rate.

8. An alien zooms by on a spaceship at half the speed of light. As he passes, he turns on a spotlight and shines it directly in front of him. At what speed do you see the light moving? At what speed does the alien see the torch light move away from him?



Einstein's 2nd Postulate states that the speed of light is constant in all inertial frames (non-accelerating frames) and is independent of the speed of the source or observer.

So you see the light fly past at $v = c = 3\times10^8$ m/s (not 1.5c as Gallilean relativity would suggest).

Also, the alien sees the light zoom away from him at $v = c = 3\times10^8$ m/s.

9. State Lenz's law.

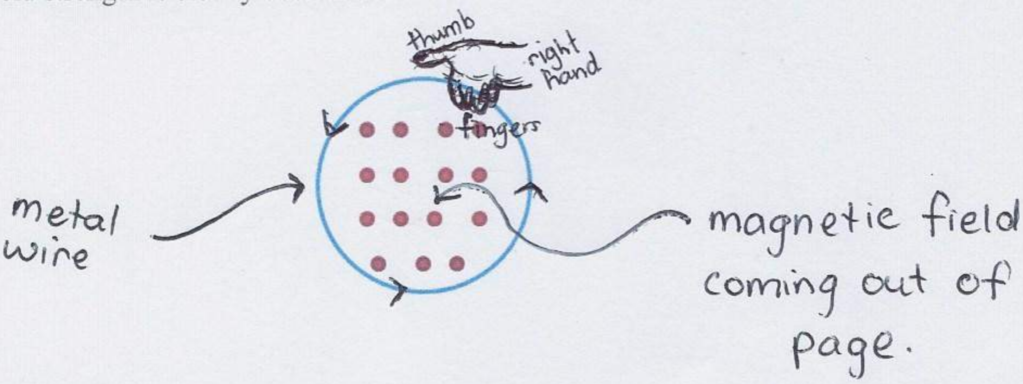
When a changing magnetic field induces an emf (voltage) in a wire, the induced emf is orientated such that it opposes the change in magnetic flux that created it.

10. A magnetic field of strength B is passing through a circular loop as shown below. With reference to Faraday's Law and Lenz's law, explain what will happen to the wire if the magnetic field strength is slowly decreased?

$V_{induced} = -\frac{d\Phi_B}{dt}$ (Faraday)

$= -\frac{d}{dt}(BA)$

$= -\frac{dB}{dt}A$

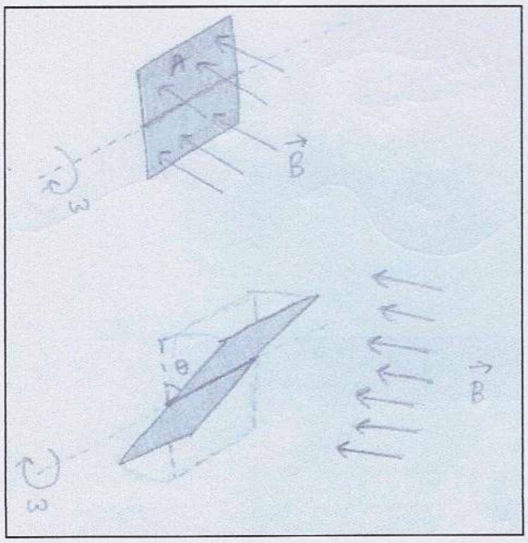


Since the magnetic field is changing, the wire will experience a change in flux and an emf will be induced in the wire (Faraday's Law). Because the wire is in a closed loop, the emf will cause an electric current to flow in the metal wire. From Lenz's Law, we know that the induced current will have an associated magnetic field that will oppose the change in flux that created it. Because the magnetic flux out of the page is decreasing, the induced current will act to increase the magnetic flux coming out of the page. From the right hand rule, we can know that the induced current will be clockwise (thumb in the direction of current, and the fingers wrap around the wire and point out of the page = B field)

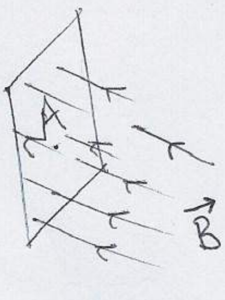
11. With reference to the set-up in question 10, why is Lenz's law really just a consequence of the law of conservation of energy?

Imagine if Lenz's Law was wrong, and the induced current in Q10 was anti-clockwise. That would mean that a decrease in strength in the $\vec{B}$ field out of the page, would induce a current whose magnetic field would act into the page. Now the loop would experience a change in magnetic flux (decreasing $\vec{B}$ field out of the page) even more rapidly than what it initially did, which would in turn induce a bigger anti-clockwise current (according to the case where Lenz's law was wrong) which would cause an even greater change in flux, and so on. An infinite electrical current would result from a finite amount of work (done to decrease $\vec{B}$). This violates energy conservation

12. A loop of wire with area A sits in the presence of a magnetic field of magnitude B. The loop can rotate with constant angular speed ω as shown in the diagram below.

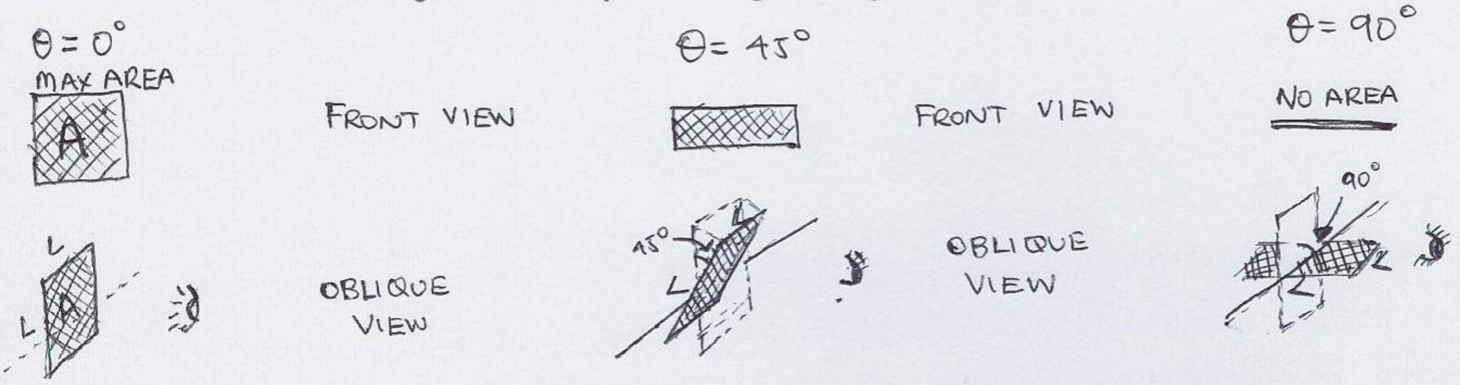


After a time t, the loop makes an angle θ with the vertical. What is the magnetic flux that passes when the loop is vertical (θ = 0)?

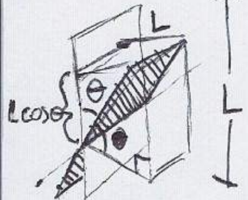


Magnetic Flux Through Loop $= \Phi_B = BA$

13. What is the magnetic flux that passes through the loop at time t?



As you can see, the amount of flux passing through the loop will vary from a maximum when $\theta = 0$ to zero when $\theta = 90°$ as the area through which the flux can travel through varies. The Area from the "front" view" is



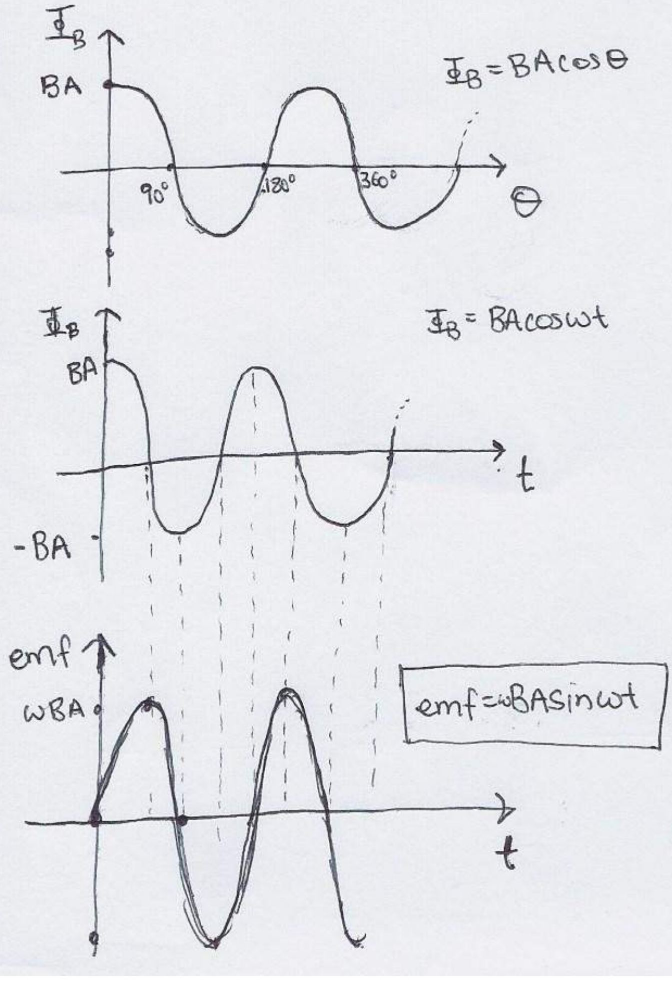
Exposed Area $A = L(L\cos\theta) = L^2\cos\theta = A\cos\theta$

$\theta = \omega t$ (since θ changes with time. This is kind of like $s = vt$ for angles)

↑ angular speed

$\boxed{\Phi_B = BA\cos(\omega t)}$ $\qquad \Phi = B\left(\text{exposed area}\right) = BA\cos\theta = BA\cos(\omega t)$

14. What is the emf (voltage) induced in the loop at time t? Graph the emf in the loop as a function of time. *This question involves differentiation!*



From Faraday's Law:

$$emf = -\frac{d\Phi_B}{dt}$$ (negative represents Lenz's law mathematically)

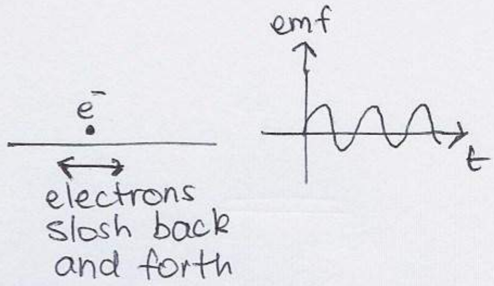
$$emf = -\frac{d}{dt}\left(BA\cos(\omega t)\right)$$

$$\boxed{emf = \omega BA\sin(\omega t)}$$

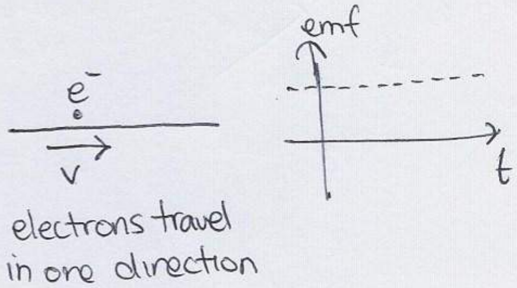
NB: The induced emf in the wire is the gradient of the Φ_B vs time graph. That is what the scary formula $emf = -\frac{d\Phi_B}{dt}$ means.

15. Is the induced current in the loop AC or DC?

AC = Alternating Current



DC = Direct Current



Question 14 involved AC!

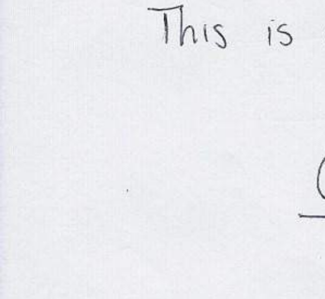
16. Is this an example of a motor or a generator?

This is an example of a **generater.**

Generator: motion in ⟶ electricity out

Motor: electricity in ⟶ motion out.

You could imagine the loop in Q12 being turned by a waterfall or something which would turn a loop which could then generate AC power for a toaster or something.



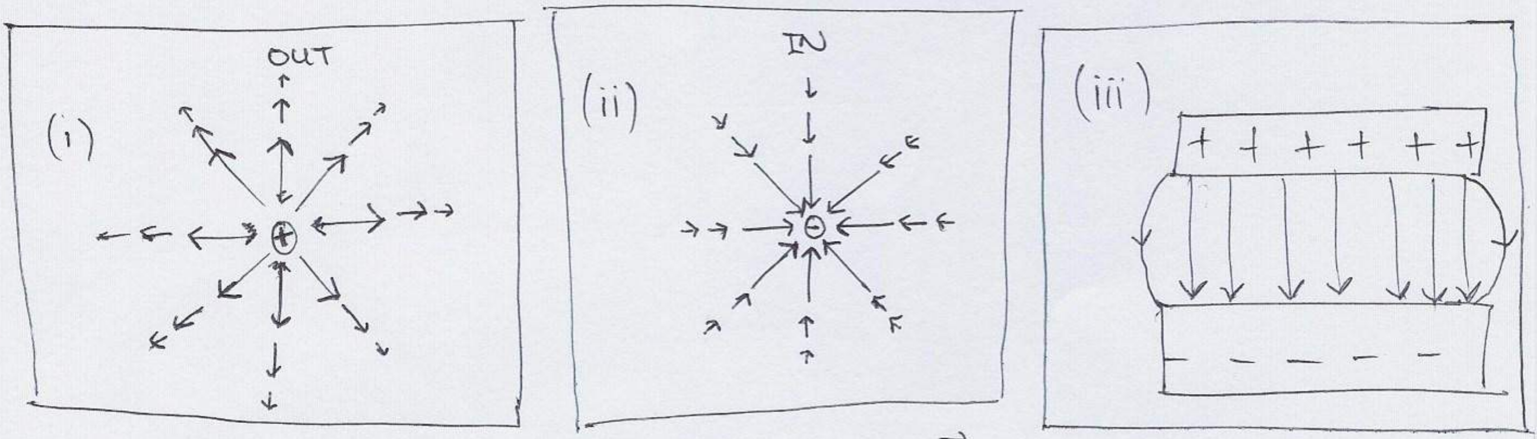
17. Define in your own words what the Electric Field is. Draw the electric field emerging from:

(i) a proton

(ii) an electron

(iii) two charged parallel plates of opposite charge.

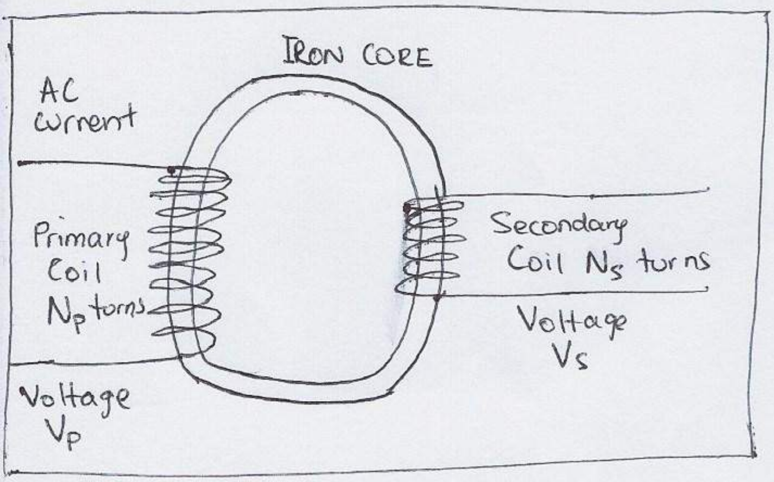
The electric field is a vector field that tells you the force that +1 C charge would feel. ($\vec{F} = q\vec{E}$).



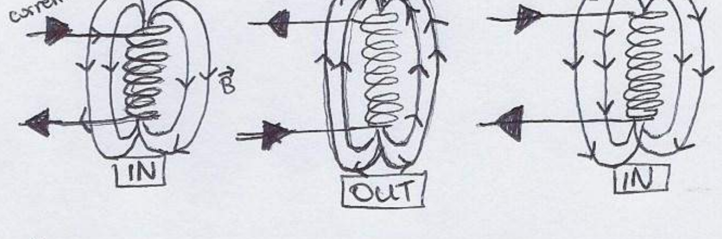
A positive charge moves with the $\vec{E}$ field arrows

A negative charge moves against the $\vec{E}$ field arrows.

18. Explain how a transformer works.



1) Alternating current in the primary coil, which means electrons in the primary coil slosh back and forth, create a constantly changing magnetic field.



2) The iron core "chanels" this changing magnetic field into the secondary coil.

3) From Faradays Law, we know that a changing magnetic field induces an emf in a present conductor. So an alternating current gets induced in the secondary coil.

4) However, V_s will not be the same as V_p (in general). This is the point of a transformer

19. Why is a transformer useful in terms of power transmission?

The electricity we use in our homes and for industry is usually produced at plants long distances away from where we use it. To get it to our homes, we use transmission lines which electrically connect the power plant to where it is used to do work in our homes and workplaces. Power is defined as the rate at which energy is released, where

$$P = IV$$

If the current in a wire increases, voltage must decrease in order to keep the power constant and conserve energy. A step-up transformer increases the voltage from one wire to the next but it keeps power constant in order to conserve energy. Thus a step up transformer also decreases the current in a electrical system. This is useful in power transmission because once we substitute Ohm's Law V = IR into the formula above we get:

$$P = I^2R$$

We see that power loss scales with the current squared. So if we can decrease current at all, then we will drastically be able to reduce power loss. If we use a step up transformer to increase the voltage, and decrease the current near the energy power plant, then that will dramatically reduce losses in power transmission. Before electricity makes it to the home or workplace, a step down transformer converts the high voltage back to 240V for use in a domestic environment.

This is how transformers are used in power transmission - to reduce power losses.

20. Two power lines on a street are 1km long, 80cm apart and carry DC electricity each with a current of 3A. What is the force that one wire exerts on the other? The power is flowing in the same direction.

$$F = L\,k\frac{I_1 I_2}{d}$$

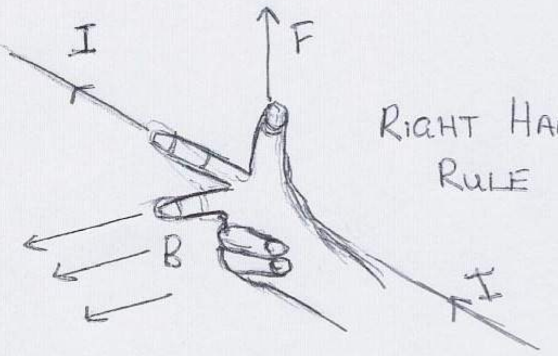
$$F = 10^3\ \ (2 \times 10^{-7})\frac{(3)(3)}{0.80}$$

$$F = 2.25\ \times 10^{-3}\ N$$

The force is attractive since the electricity is flowing in the same direction. If the two wires had electricity flowing in the opposite direction, the force would be repulsive

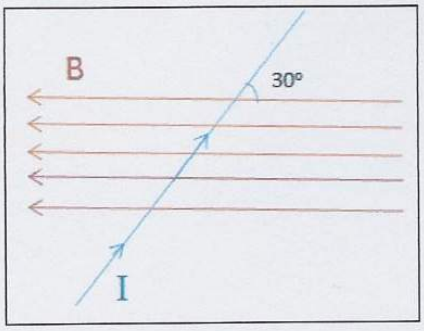
21. Define the motor effect.

Motor effect: a current carrying wire in the presence of a magnetic field will experience a force



- The right hand rule tells you what direction the force will act
- IMPORTANT: This applies to conventional current (positive charges moving from ⊕ to ⊖). For negative charges, use your left hand!

22. A wire carrying a 2A current sits in a magnetic field of strength 0.2 mT as shown below. What force does the wire experience and in what direction?



Using the right hand rule, we know the force will act out of the page.

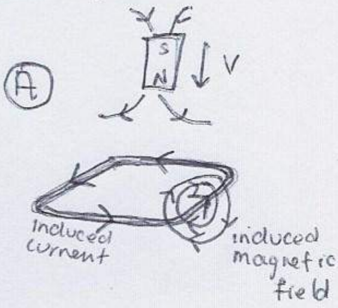
$$F = BIL\sin\theta$$

$$\frac{F}{L} = BI\sin\theta = (0.2 \times 10^{-3})(2)(\sin 30°)$$

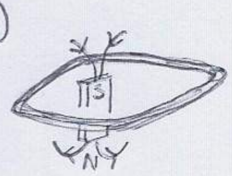
$$\frac{F}{L} = 2 \times 10^{-4} \ N/m.$$

Note that this is actually the force per metre of wire (sorry the question asked for Force only). So if the wire was 1m long, it would experience a 2×10^{-4} N force out of the page.

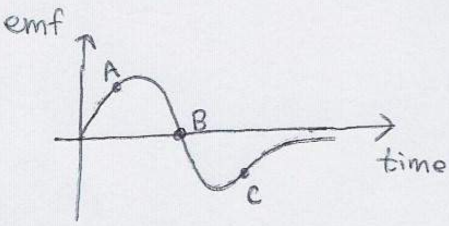
23. A magnet is dropped into a loop of wire and falls out the bottom. Using diagrams to aid your curve, sketch the graph of the induced emf in the loop as a function of time. Explain your graph with reference to both Faraday's Law and Lenz's Law.



(A) The loop begins to experience an increase in flux coming through from the top. Faradays Law says this will induce an emf in the wire. Lenz Law says the induced current will act to decrease the magnetic field acting downward so is orientated as shown.

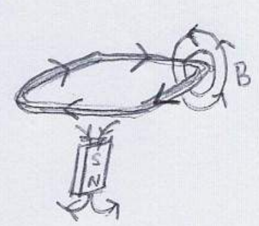


(B) Intermediate case: flux is kind of constant (no emf)



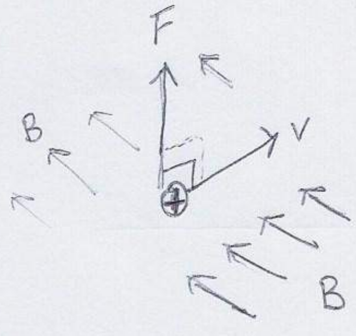
Arbitrarily define upwards to be positive (clockwise when viewed from above)

(C) As the magnet recedes, less and less flux passes downwards through the wire. The induced B field will act to increase the flux down through the wire (lenz law)



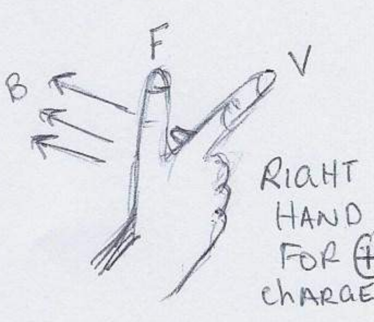
24. Justify why the force that a charged particle experiences in a magnetic field qualifies as a centripetal force.

- A centripetal force is any force that acts perpendicular to an objects velocity.



- When a charge is moving in an magnetic field it experiences a force at 90° to its velocity

- Thus a charge particle moving in a magnetic field experiences a centripetal force, consequently making it follow a circular path (provided $V \perp B$)



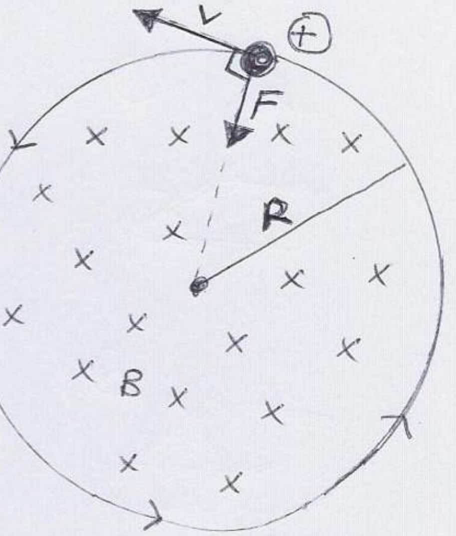
25. Derive an expression for the radius of the circle that the charge particle will travel on.

$F_{magnetic} = qvB$, $F_{centripetal} = \frac{mv^2}{R}$

Equating $F_{magnetic}$ with $F_{centripetal}$:

$$qvB = \frac{mv^2}{R}$$

$$\boxed{R = \frac{mv}{qB}}$$



Use Right Hand Rule for positive charges.

26. Show that the amount of time it takes for the charge to complete one full revolution is independent of how fast it is moving.

$$\text{Speed} = \frac{\text{Distance}}{\text{Time}}$$

$$\text{Time} = \frac{\text{Distance}}{\text{Speed}}$$

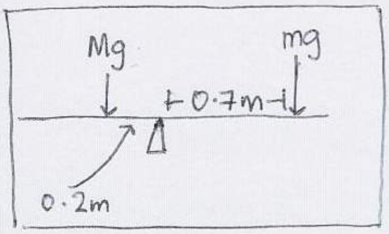
The distance the charge travels in one complete circular revoulotien is given by $2\pi R$, so we have:

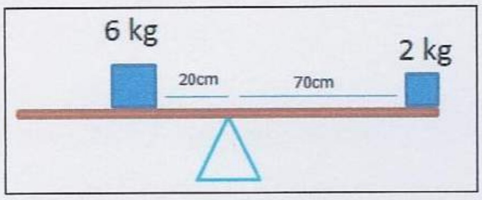
$$T = \frac{2\pi R}{v} = \frac{2\pi\left(\frac{mv}{qB}\right)}{v}$$ using $R = \frac{mv}{qB}$ from Q25

$$\boxed{T = \frac{2\pi m}{qB}}$$

This expression does not depend on velocity. The mass and charge of the particle so the only thing that effects how long a revoloutien takes is B, the magnetic field strength.

27. Will the see-saw below rotate clockwise, anticlockwise or not at all? Validate your answer with calculations involving torque.





Arbitrarily define ↻ clockwise to be positive.

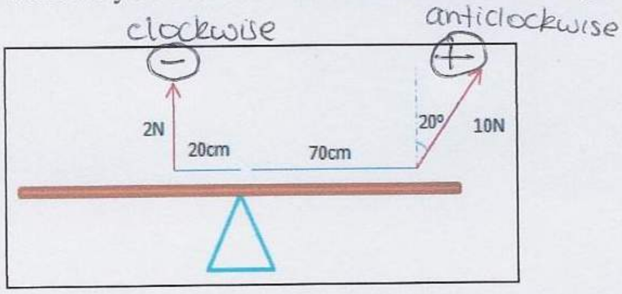
The 6kg mass is making the see-saw ~~the se~~ rotate ANTI CLOCKWISE SO IS NEGATIVE

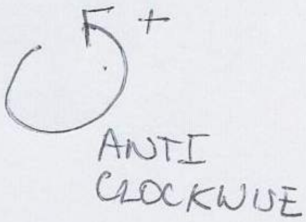
The 2kg mass is making the see-saw rotate CLOCKWISE SO IS POSITIVE

Net Torque $= \tau = -Mgd_1 + mgd_2 = -(6)(9.8)(0.2) + (2)(9.8)(0.7) = 2.96\,\text{Nm}$

The net torque is positive meaning that it will rotate clockwise.

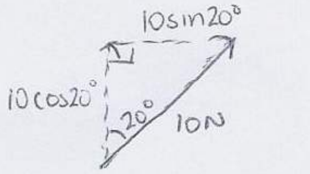
28. A see-saw below is pulled as shown below. Will the see-saw rotate clockwise, anticlockwise or not at all? Validate your answer with calculations involving torque.





Again, we define an orientation to be positive. To show that it doesn't matter which way, I'll choose ANTI-CLOCKWISE to be POSITIVE ↺ this time.

In torque calculations, we're only interested in the forces that are 90° to the "moment arm" (the see-saw in this question).



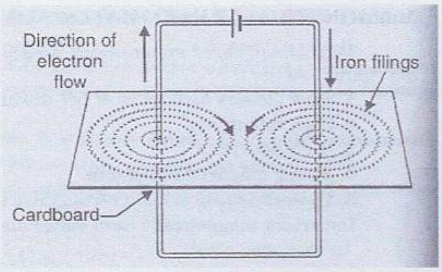
Net Torque $= \tau = -2(0.2) + (0.7)(10)\cos 20°$

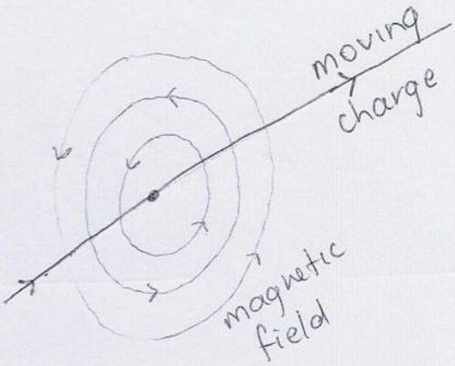
Net torque = 6.18 Nm which is POSITIVE

meaning that it will rotate ANTI-CLOCKWISE

29. Iron filling sit on a flat piece of cardboard. The horizontal cardboard has a wire punched through it which runs vertically (at right angles to the cardboard). What will the iron fillings do when electric current runs through the wire?

- Iron fillings line up with the magnetic field lines.

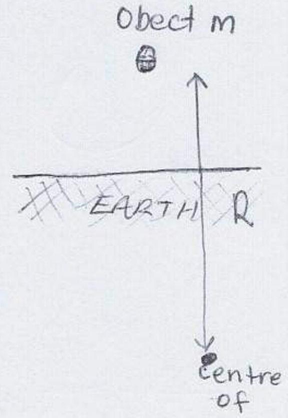




- Michael Faraday did this.
- It occurs because all moving charges create a magnetic field on a plane perpendicular to their velocity

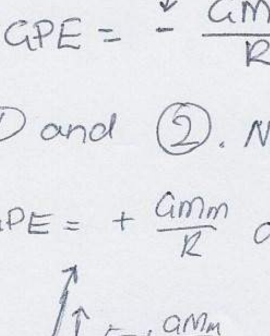
30. Explain why we denote gravitational potential energy as negative.

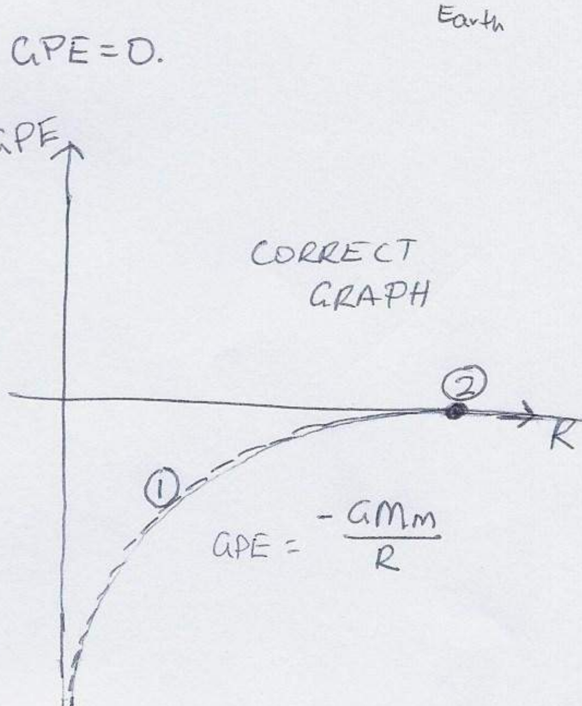
① • As we move the object of mass m above the Earth's surface, it will gain more and more potential energy so GPE increases with distance.
(so curve is always increasing with distance)



② • However, as we move the object to infinity, or a very long distance away, the force of attraction goes to zero ($F = \frac{GMm}{r^2}$), so when $R = \infty$, $GPE = 0$.

The graph of $GPE = -\frac{GMm}{R}$ (negative) satisfies conditions ① and ②. Note that the graph of $GPE = +\frac{GMm}{R}$ doesn't satisfy condition ①





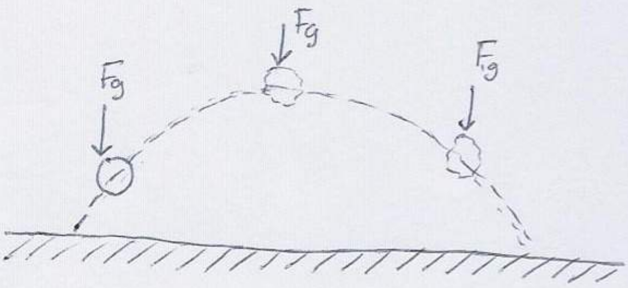
31. In the absence of air resistance, a projectile has:

A) constant horizontal acceleration and constant vertical velocity

(B) constant horizontal velocity and constant vertical acceleration

C) constant horizontal displacement and constant vertical acceleration

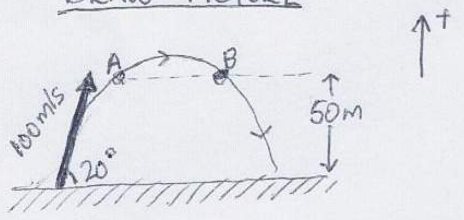
D) constant horizontal velocity and constant vertical displacement.



The only force acting on the projectile is gravity F_g, which only acts vertically. So the vertical velocity changes (accelerates) but the horizontal velocity is constant.

32. A tennis ball is launched from sea level at 100m/s at an angle of elevation of 20°. Ignoring air resistance, it will be at a height of 50 metres above sea level at two different points in time. What are these two points in time?

Step 1 // DRAW PICTURE



Step 2 // STATE KNOWNS AND UNKNOWNS

Vertically:

$u = 100 \sin 20°$ m/s

$s = 50$ m

$a = -9.8$ m/s²

$t = ?$

Horizontally:

$u = 100 \cos 20°$ m/s

$a = 0$

Step 3 // PICK WHICH FORMULA

1. $v = u + at$
2. $v^2 = u^2 + 2as$
3. $s = ut + \frac{1}{2}at^2$

We need to know t. If we use (3), we can substitute s, u and a and solve for t

Step 4 // SUB IN VALUES

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

$50 = (100 \sin 20°)t + \frac{1}{2}(-9.8)t^2$

$4.9t^2 - 34.202t + 50 = 0$

Using the quadratic formula

$$t = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

$$= \frac{34.202 \pm \sqrt{34.202^2 - 4(4.9)(50)}}{2(4.9)}$$

$= 2.08$ s AND 4.90 s

Step 5 // SUMMARISE

At $t_1 = 2.08$ s and $t_2 = 4.90$ s the ball is 50m high.

33. How far horizontally will it have travelled when the ball reaches its maximum height.

Vertically

At peak height

$a = -9.8$

$v = 0$

$u = 100\sin 20^\circ$

$t = ?$

$v = u + at$

$t = \frac{v - u}{a}$

$t = \frac{0 - 100\sin 20^\circ}{-9.8} = 3.49\,s$

Horizontally

At peak height

$a = 0$ $u = 100\cos 20^\circ$

$s = ?$

$t = 3.49$

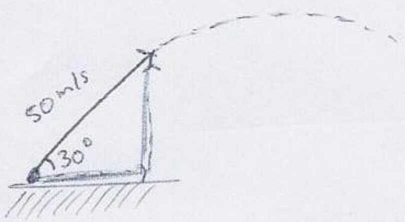
$s = ut + \frac{1}{2}at^2$

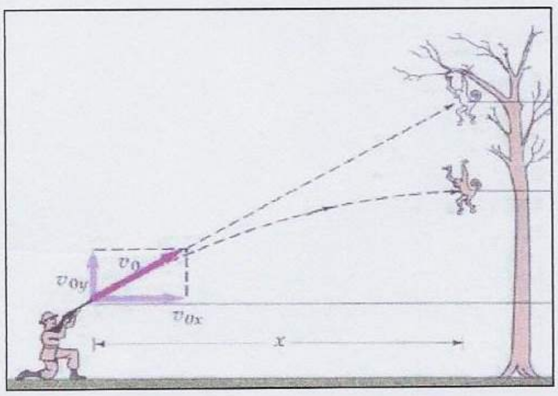
$s = (100\cos 20^\circ)(t) + \frac{1}{2}(0)t^2$ (t = 3.49)

$s = 327.952\ldots m$

$s = 328$ (3 sig figs)

34. A hunter is pointing his gun at a monkey in a tree as shown in the diagram below. The gun is pointed at an angle of 30° above horizontal and fires a bullet a 50 m/s. The base of the tree is 200 metres away from the hunter. In order to avoid being shot, the monkey lets go of his branch the moment the gun is fired. How long will it take for the bullet to travel 200 metres horizontally?





Horizontally

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

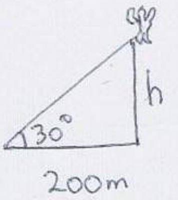
$(200) = (50\cos 30^\circ)t + \frac{1}{2}(0)t^2$

$t = \frac{200}{50\cos 30^\circ}$

$t = 4.618802\ldots s$

$t = 4.62s$ (3 sig figs)

35. How high will the monkey be after that amount of time has passed?



The monkeys initial height:

$\tan 30° = h/200$

$h = 200 \tan 30°$

$h = 115.4700... m$

Vertically

$a = -9.8 m/s^2$ $S_{initial} = 115.47m$

$u = 0$

$t = 4.62s$

$s_{final} = ?$

$S_{final} = S_{initial} + ut + \frac{1}{2}at^2$

$= 115.4700 + (0)(4.62) - \frac{1}{2}(9.8)(4.62^2)$

$= 10.9367.... m$

$S_f = 10.9 m$ (3 sig figs)

The monkey will be 10.9m high when the bullet travels 200m horizontally.

36. How high above the ground will the bullet be after that amount of time?

Vertically

$s = ?$

$t = 4.618802 s$

$u = 50 \sin 30° = 25 m.s^{-1}$

$a = -9.8 m/s^2$

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

$= (25)(4.62) + \frac{1}{2}(-9.8)(4.62^2)$

$= 10.9367... m$

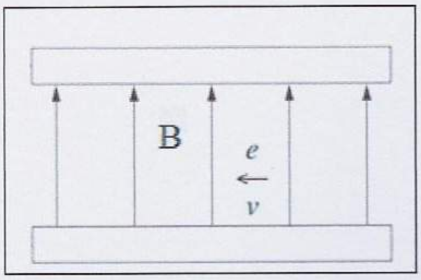
$s = 10.9m$ (3sig figs)

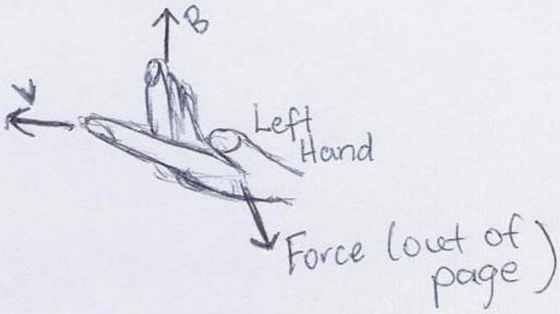
Note that at $x = 200m$ when $t = 4.62s$, both the monkey and the bullet are at the same height i.e. he gets shot.

37. Is the monkey doomed whether he lets go or not?

Yes. If the monkey lets go the instant the shot is fired, he is doomed. To survive, he needs to let go before or after the shot.

38. In the diagram below, in what direction will the electron experience a force?





Out of the page. Use the left hand rule for negative charges (right hand for ⊕ charges)

39. What is the magnitude of this force given it's moving at 10 m/s in a 2T field?

$$F_B = qVB$$

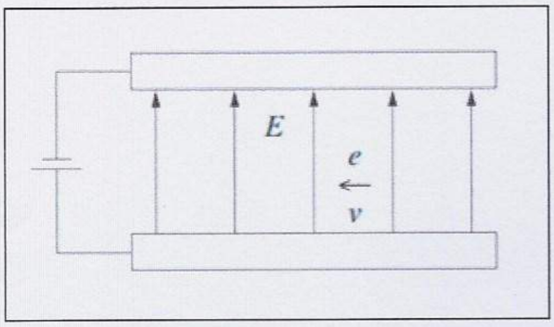
$$= (1.602 \times 10^{-19})(10)(2)$$

$$= 3.204 \times 10^{-18} \text{ N}$$

directed out of the page

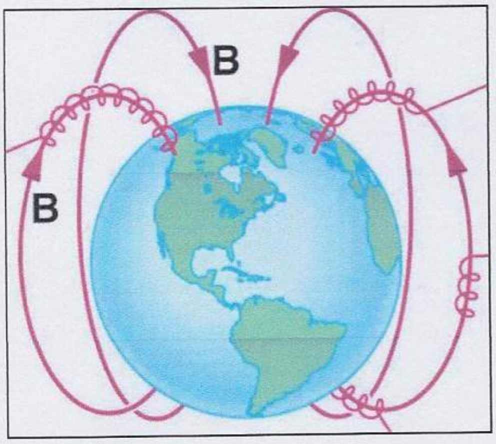
So the magnitude is 3.204×10^{-18} N.

40. In the diagram below, in what direction will the electron experience a force?

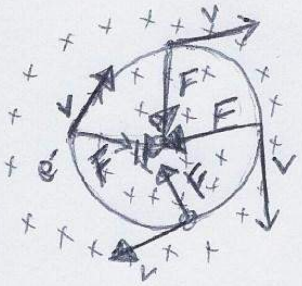


Downwards. Positive charges feel a force in the same direction as the electric field lines. Negative charges feel a force in the opposite direction as the electric field lines.

41. Charged particles ejected from the sun get funnelled towards the Earth's north and south pole. Account for why these particles spiral around the Earth's magnetic field lines, as shown below.

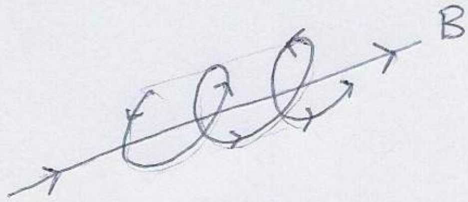


2D Case



Force is always perpendicular to velocity and so is a centripetal force. Causes circular motion

3D Case



Like in the 2D case, the particle experiences a force towards the centre of helix (the magnetic field line). However in 3D, the particle has a 3rd component of velocity which makes it "spiral" instead of circulate.

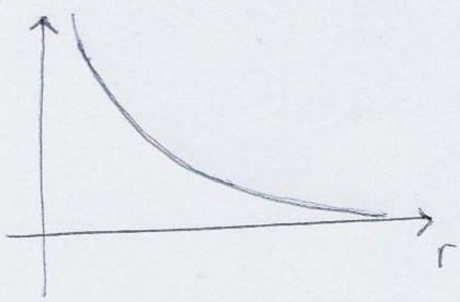
42. Why does the weight of an astronaut change as she moves from the Earth's surface and into outer space?

$W = mg$. However g decreases as she moves away from the earth's surface which means that W decreases as she moves into outere space.

43. Graph her weight as a function of distance away from the Earth's surface and give a mathematical relation to support your graph.

Weight is the force that the Earth's gravitational field exerts on her. It is given by:

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



44. A human can extract 2300 kJ of energy from a Big Mac. How many red photons (of wavelength 700nm) are needed to have more energy than a Big Mac?

$E = hf$ ..... (1)

$c = f\lambda \Rightarrow f = \frac{c}{\lambda}$ .... (2)

Substitute (2) into (1):

$$E = \frac{hc}{\lambda}$$

RED PHOTON

$$E = \frac{hc}{\lambda} = \frac{(6\cdot626\times10^{-34})(3\times10^{8})}{700\times10^{-9}} = 2\cdot8397\times10^{-19}\,J$$

$$\frac{2300\times10^{3}}{2\cdot8397\times10^{-19}} = 8\cdot1\times10^{24}$$

Therefore $8\cdot1\times10^{24}$ red photons have the same energy as a Big Mac

45. How much more energy does a blue photon (wavelength 470nm) have than a red photon?

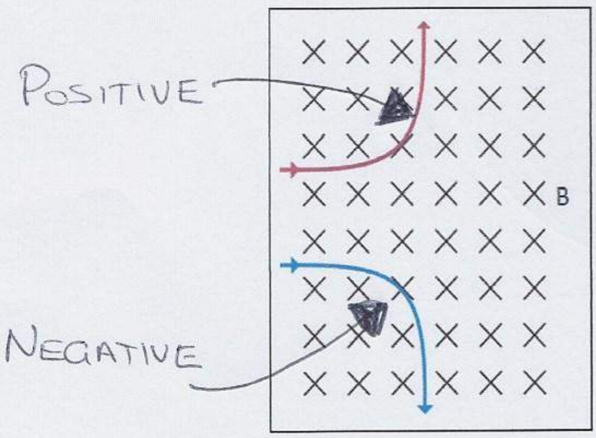
$$E_{\substack{red\\photon}} = 2.8397 \times 10^{-19}\ J$$

$$E_{\substack{blue\\photon}} = \frac{hc}{\lambda} = \frac{(6.626 \times 10^{-34})(3 \times 10^{8})}{(470 \times 10^{-9})} = 4.22936 \times 10^{-19}\ J$$

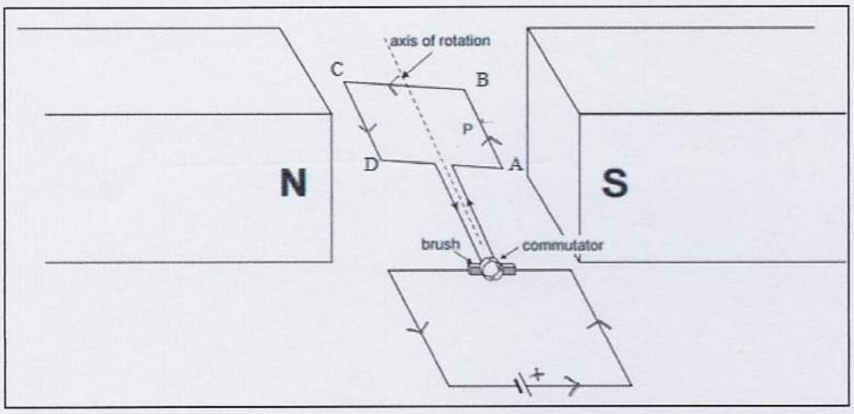
$$\frac{E_{blue}}{E_{red}} = \frac{4.22}{2.83} = 1.49$$

Therefore blue photons have 149% the energy of a red photon.

46. Which charge is positive and which charge is negative?



47. Which arms of the aperture below experience a force and in what direction?



POSITIVE CHARGES FLOW FROM A → B → C → D

AB: Force downwards

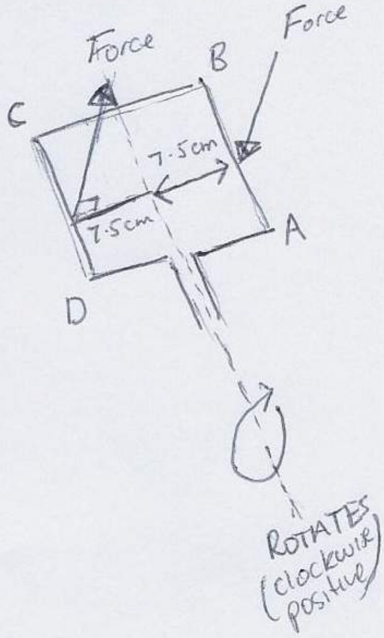
BC: Doesn't experience a force

CD: Force upwards

DA: Doesn't experience a force

} When current is parrallel to magnetic field lines, the wire doesn't experience a force.

48. If all sides of the above square aperture are 15cm long, the magnetic field is 0.5mT and a 4A current runs through the aperture, what is the output torque of the motor?



$F_{AB} = BIL = (0.5\times10^{-3})(4)(0.15) = 3\times10^{-4}$ N DOWN

$F_{CD} = BIL = (0.5\times10^{-3})(4)(0.15) = 3\times10^{-4}$ N UPWARD

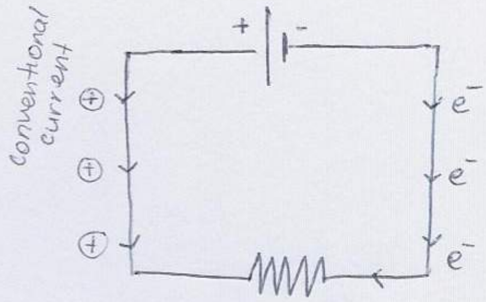
NET TORQUE $= F_{AB}\, d_{AB} + F_{CD}\, d_{CD}$

$= (3\times10^{-4})(0.075) + (3\times10^{-4})(0.075)$

$\tau = 4.5\times10^{-5}$ N.m.

49. Outline the difference between electron current and conventional current.

Electron Current:
- travels from negative to positive
- electrons carry the charge
- is actually what happens in reality



Conventional Current:
- travels from positive to negative
- isn't what happens in reality
- It's what physicists use most of the time
- It's what we do for historical reasons

50. Assuming the rocket provides constant thrust during take-off, explain why astronauts will experience increasing g-forces as they ascend into outer space.

From Newton's 2nd Law: $a = \frac{F}{m}$.

As the rocket burns fuel, the rocket looses mass. However thrust (F) remains constant. To balance Newton II, "**a**" must also change, and increases as the rocket ascends.

G-forces is related to acceleration by:

$$g\,force = 1 + \frac{a}{g}$$

So increasing acceleration, increases the g forces experienced by the astronauts.