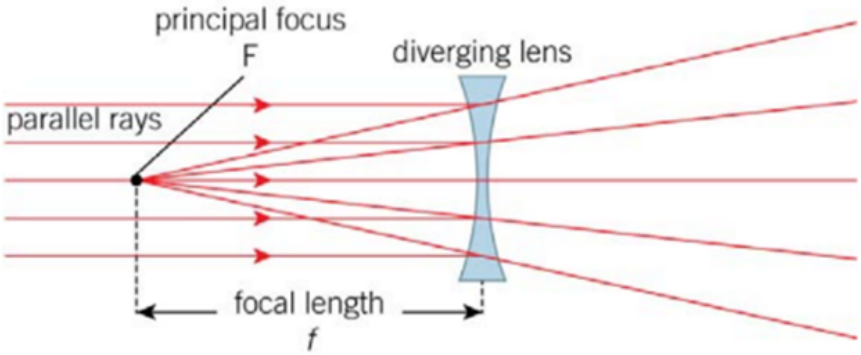
1.	What must the forces in Newton's Third Law be?	Of the same type. Covered elsewhere
2.	What does an ideal voltmeter measure around a cell?	Terminal p.d. Not true since ideal.
3.	What is the principal focus / focal point in a diverging lenses?	The point where diverging rays from rays parallel to the principal axis appear to come from.  Don't need to know abotu diverging...
4.	Justify Kirchhoff's Second Law	Each charge carrier **must transfer all its energy** within the circuit and **return to the cell with none** remaining. Del.

5. What is Gravitational Potential defined as with its equation? DELETE

The gravitational potential energy per unit mass (Jkg^{-1}) at a point OR the work done per unit mass to move an small mass from infinity to a point.

$$V = \frac{-GM}{r}$$

Where V is the the gravitational potential, G is the gravitational constant, M is mass of the object causing the gravitational field, r is the distance to that mass.
This equation is the case as its the area underneath the force-distance graph:

$$W = \int_{\infty}^{r} F\,dr$$

$$= Gm_1m_2 \int_{\infty}^{r} \frac{1}{r^2}\,dr$$

$$= Gm_1m_2\left[-\frac{1}{r}\right]$$

$$E_p = -\frac{Gm_1m_2}{r}$$

---

6. Why do quasars not pose a risk to us?

As not many stars remain near the Milky Way or Andromeda's black holes.
Delete.

---

7. What is work done?

The force multiplied the displacement in the direction of the force.
Delete.

---

8. How do longitudinal waves 'map' onto transverse waves?

- Areas of **compressions** become **peaks**.
- Areas of **rarefactions** become **troughs**.
Thus the amplitude will be half the distance between the two.
Delete

---

9. How does atmospheric refraction affect angular separation?

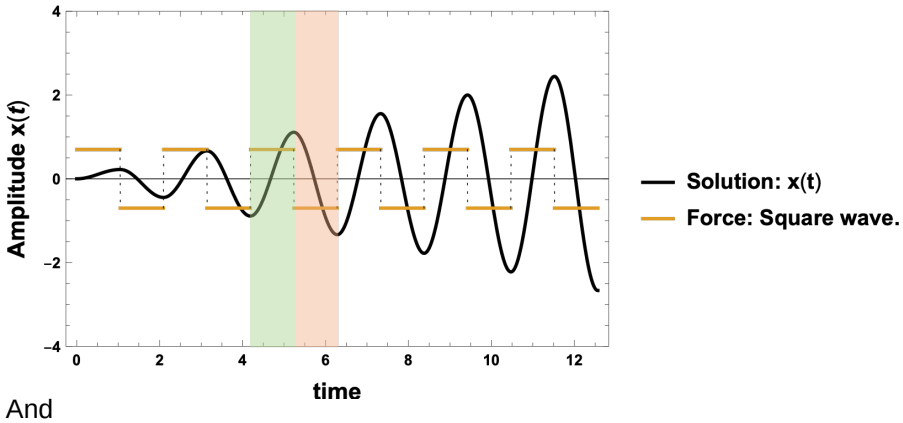
Atmospheric refraction means ground-based telescopes don't meet their theoretical value.
Delete

---

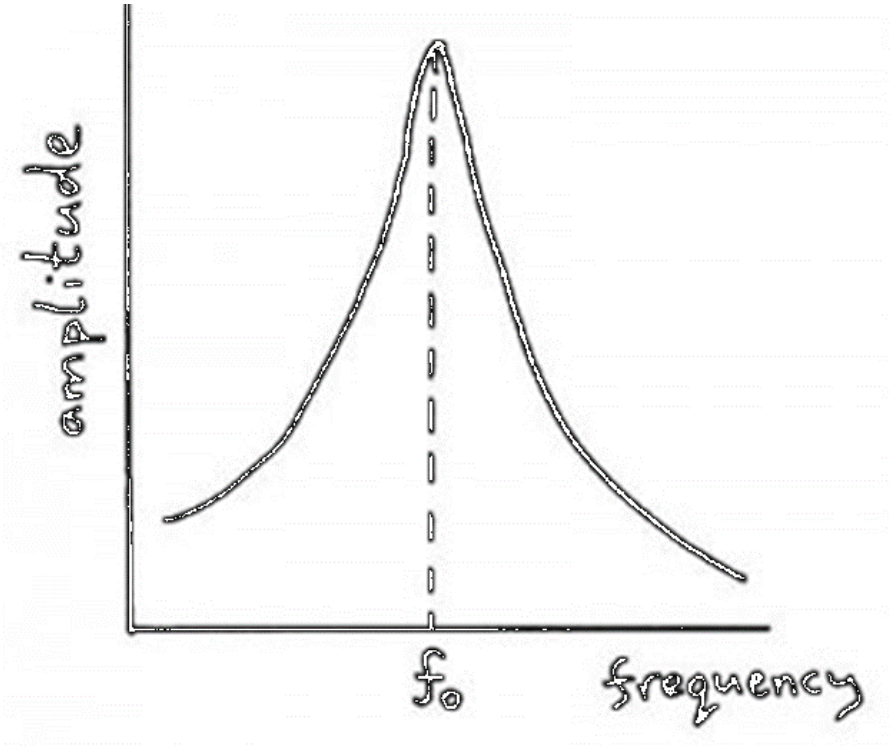
10. What is the basis of circular motion?	A body pulled inwards is moving so fast sideways that the force pulling it inwards changes the direction of motion rather than the magnitude of velocity. Delete
11. Why are filament lamps more likely to fail when switched on?	Since the resistance is lower (1) so the initial current is larger (1) leading to a sudden temperature increase (1). *Imagine the graphs here.*
12. What is electromotive force (ε)?	The energy transferred (1) by the cell per unit charge (1).
13. What is the work function?	The minimum energy required to remove an electron from the surface of a specific metal.
14. What is tensile stress (σ)?	The force applied per unit **CROSS-SECTIONAL AREA**: $$\text{stress} = \frac{F}{A}$$ *This differs from pressure in that an object under stress is pulled rather than pushed.*
15. What does ductile mean?	It can be deformed plastically. *Plastically meaning that it WON'T return to its original length.*
16. What is ionisation energy defined as?	The minimum energy required to remove an electron from its **GROUND STATE** to form an ion.
17. Explain why the minimum intensity is not zero between 2 maxima when the intensity of light coming through each slit is the same	- Intensity of the wave decreases with distance (1) as waves are travelling further. - Some waves will travel further than others (1). - The amplitudes/intensities aren't equal so they don't cancel out completely (1).
18. What is non-uniform circular motion?	Having tangential acceleration as well as perpendicular acceleration. The net force is a combination of the centripetal force and the F_{net} = ma of the tangential acceleration. *This can be found when gravity is pulling a bucket down when spinning vertically AND when something speeds up when it begins spinning. With this, you have angular acceleration (the rate of change of angular speed).*

19. What is resonance? When does it occur (phase difference)?

- When the frequency of osciilator = natural frequency of system (1) large amplitude vibrations (1) with maximum energy transfer rate (1).
- Occurs when displacement driver leads displacement driven by 90°:



And



The driving frequency of the oscillator is plotted on the x-axis.

---

20. Why doesn't speed change under circular motion?

Force acts towards centre (1) perpendicular to velocity (1) so movement done in direction of force (1) so no work done so no change in K_E so change in speed (1)

---

21. Why does an increase in temperature increase resistance?

Particles vibrate **more frequently** (1) ∴ **collide more frequently** with charge carriers (1) preventing them from flowing through so easily.

---

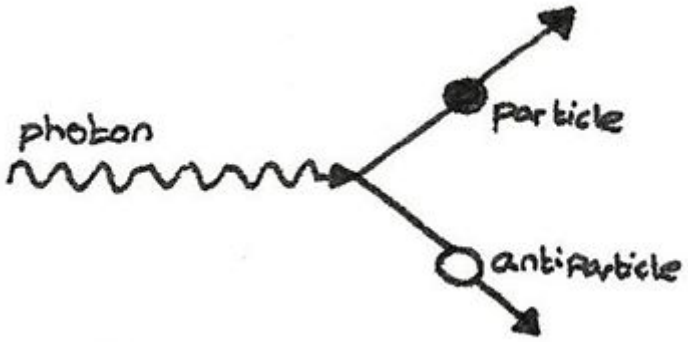
22. Give an example of a semiconductor

A thermistor.

---

23. What is pair production?

When a photon interacts with an electron / nucleus / atom (1) and has enough energy to produce a particle and its antiparticle (1) produced in pairs to conserve momentum / lepton number / charge (1).



It should be stressed that: any surplus energy becomes kinetic energy and the photon has to interact with something as it's massless

---

24. What is a meson?

A hadron consisting of a quark and an antiquark.

---

25. What is the equation linking $E_{k\ (max)}$ to stopping potential?

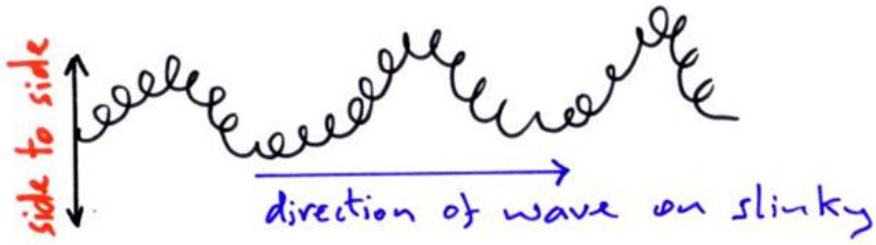
$$E_{k(max)} = e \cdot V_s$$

As V = E/Q, multiplying it by the charge of an electron gives J.

---

26. Describe the motion of transverse waves

The direction of **vibrations** are **perpendicular** to the **direction of energy propagation**.



E.g., a seagull bobbing up and down in water.

---

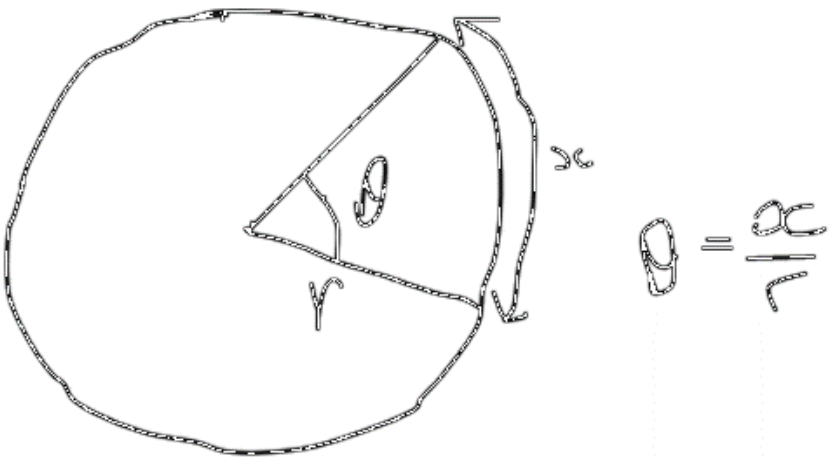
27. What 4 observations made under the Photoelectric Effect support the particle theory over the wave theory?

1. Electrons are only emitted above a threshold frequency (f_0); irrespective of intensity.
2. The $K_{E\ (max)}$ of emitted electrons depends on the frequency of EM radiation.
3. The no. of photoelectrons emitted per second depends on the intensity of EM radiation.
4. Low intensity EM radiation (above f_0) results in the immediate emissions of electrons.

---

28. How is a radian calculated, what is it defined as, and how can it be converted to degrees?

-Dividing the arc length by the radius.



Hence, 360° = 2πr/r =2π.

- Thus, one radian (when x = r) is defined as “the angle subtended at the centre of the circle by an arc equal in length to the radius”.
- Since 360° = $2\pi^c$, 1^c = 360/2π. To convert from radians to degrees, multiply by this.

---

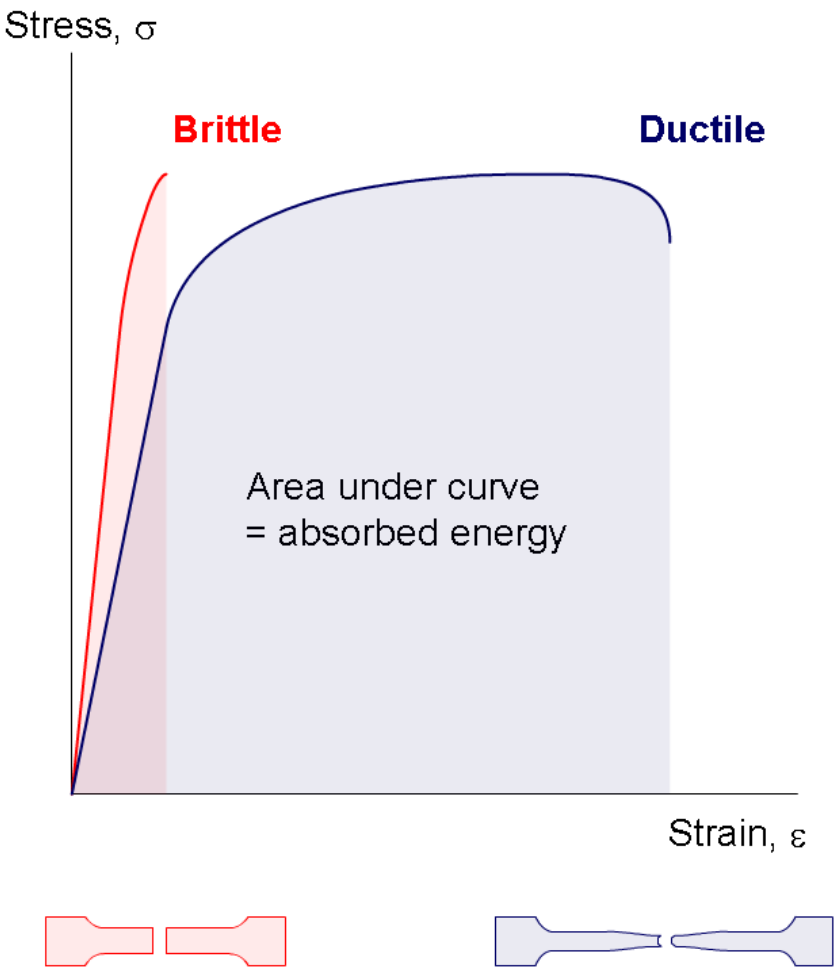
29. What is centripetal acceleration equal to?

$$a = \frac{v^2}{r} = \omega^2 r$$

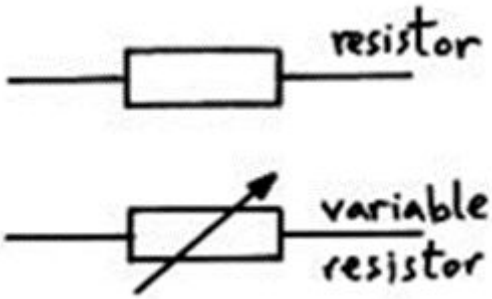
---

30. What does the area under a stress-stain graph represent?

Work done per unit volume.



31. What is the circuit symbol of both a resistor and variable resistor?



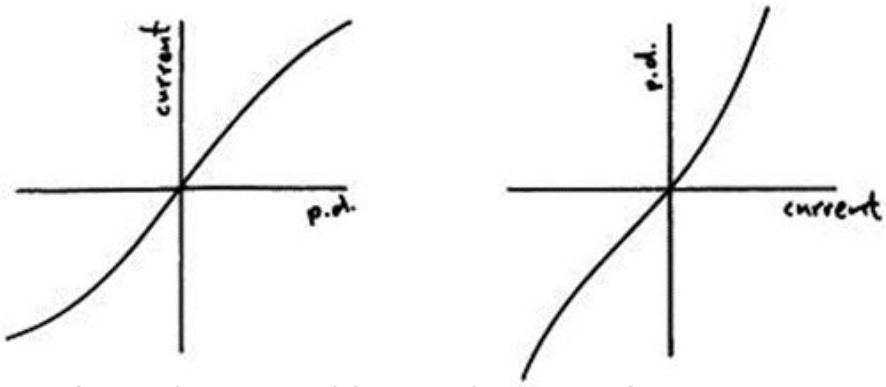
32. Why does resistance lead to the material heating up?

Energy is **transferred** during the **collisions** between the charge carriers and the positive ions.

33. What is a non-ohmic conductor?

A conductor whose resistance isn't constant.

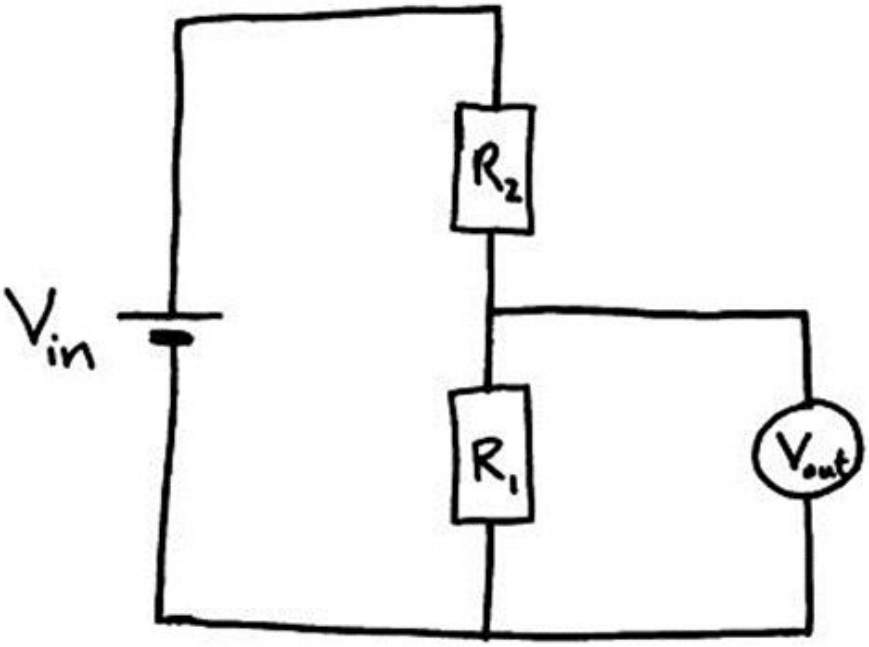
34. Give the current-voltage graph of a filament bulb with an explanation



Its **resistance** increases as it heats up due to **wasted energy**.

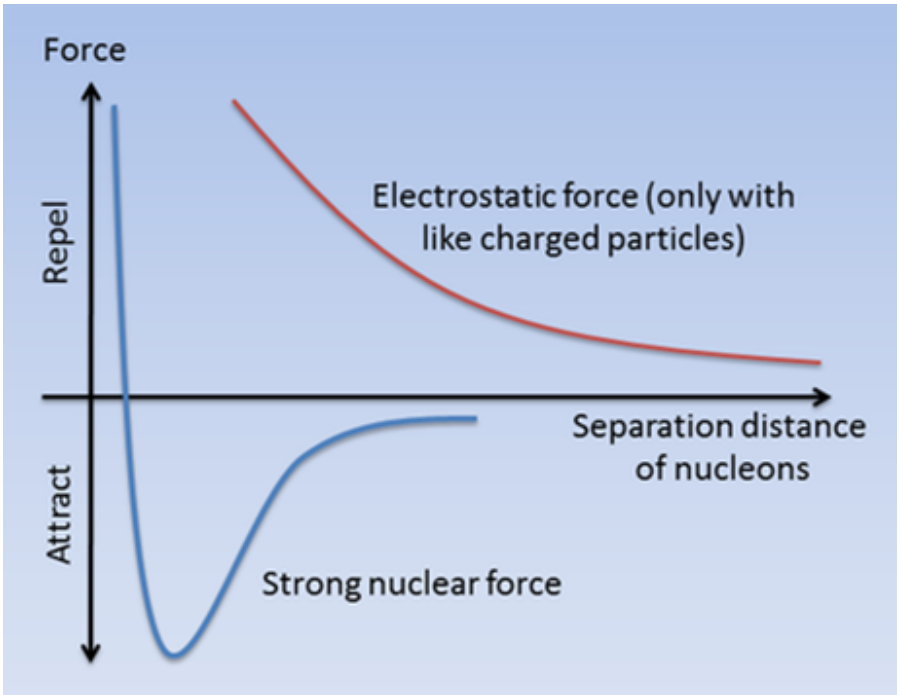
35. Give a developed application of a potential divider

Temperature control. E.g., for the diagram below, if R_1 is a thermistor, when it gets colder, its resistance increases ⇒ the its p.d. (V_{out}) increases too which could then be used to turn on a heater.



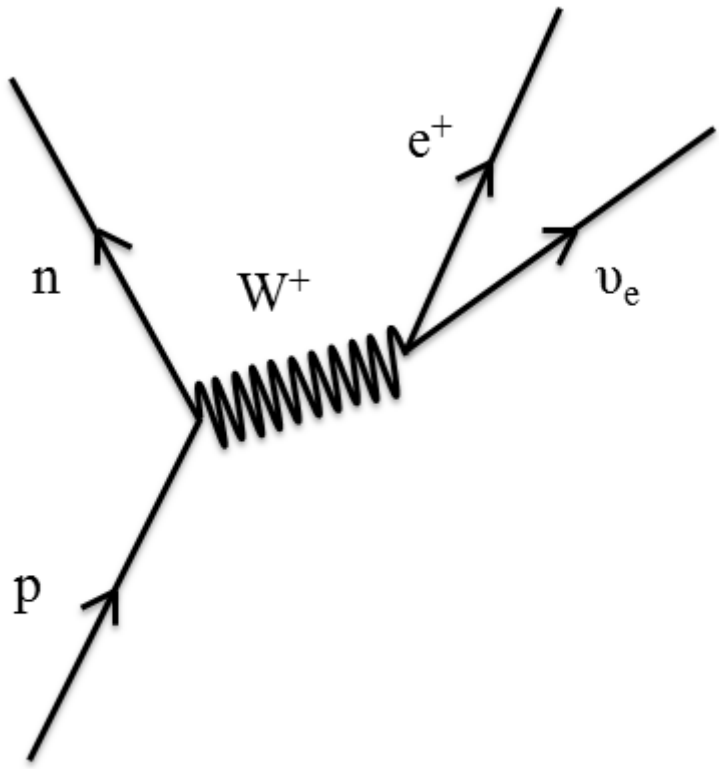
36. What does strong nuclear force give rise to and at which distances?

- Very short range attraction up to 3 fm.
- Balanced attraction between the strong nuclear force and electrostatic force at 1.5 fm.
- Very short range repulsion under 0.5 fm.
-This is all between individual nucleons.



The very short range repulsion prevents nucleons collapsing into singularities.

37. What is the Feynman Diagram for beta plus decay?

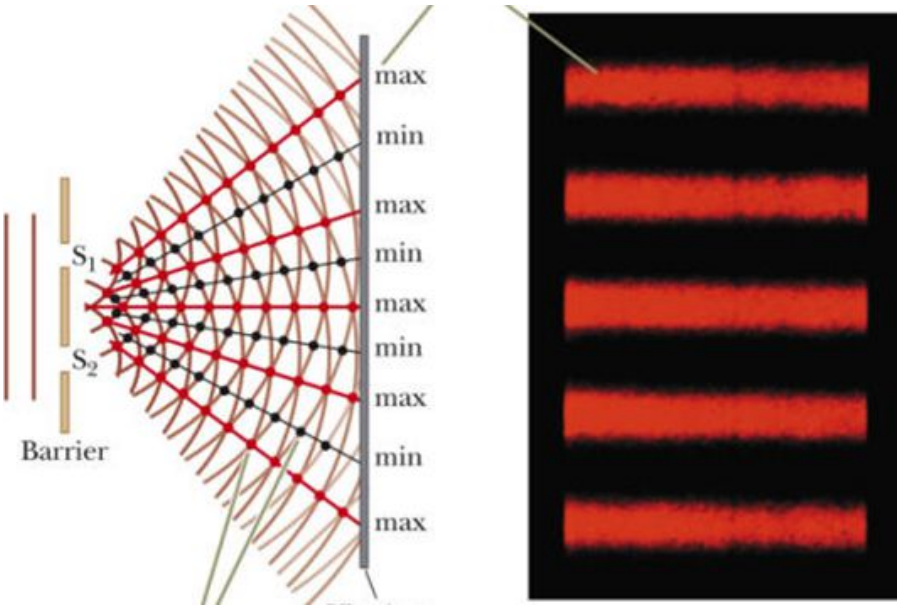


$$p \rightarrow n + e^{+} + \upsilon_e$$

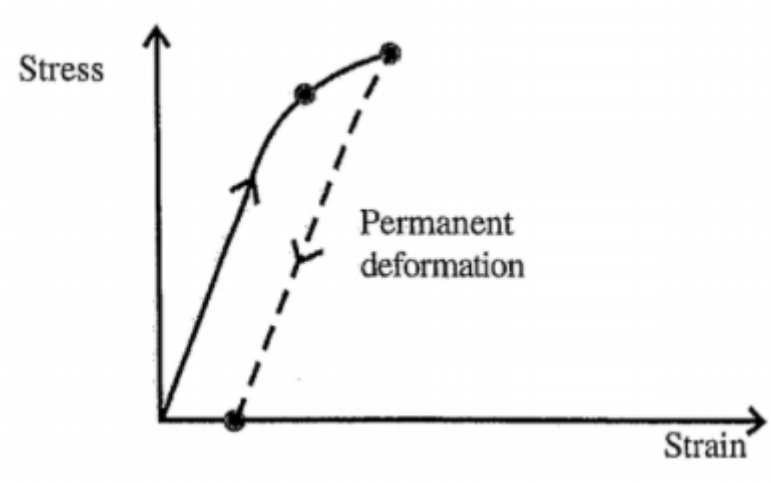
38. What 4 properties are usually conserved in particle physics?	Charge, baryon number, lepton number **OF EACH FAMILY**, and strangeness (only for the strong interaction). *This is alongside energy and momentum.*
39. What does the strong force / strong interaction act between?	Quarks (∴ all hadrons).
40. How does changing the amplitude and wavelength affect particles on a longitudinal wave?	- **Increasing** the **amplitude** makes particles **vibrate further** from rest position. - **Increasing** the **wavelength increases** the **distance between consecutive areas** of compression/rarefaction.

41. What occurs at each type of fringe under Young's Double Slit?

-At the light fringes, constructive interference.
-At the dark fringes, destructive interference.



42. Sketch and describe the loading-unloading stress-strain graph for a metal wire obeying Hooke's Law past the elastic limit



- Wire has been permanently stretched ∴ longer for a given load.
- Gradient is same as identical forces between bonds.
- Area between is the **energy required per unit volume** to permanently deform the wire as this energy isn't recovered.

43. What is the principle of the conservation of momentum?

"When two objects interact, the total momentum remains the same provided no external forces are acting."

External forces include friction. They affect the total momentum as they can reduce the velocity of an object.

44. Describe standing/stationary waves (2)

- Waves that have no net transfer of energy from one point to another.
- The amplitude varies from zero at the nodes to a maximum at the antinodes.

45. What is angular speed (ω)?

The angle (θ, measured in radians) an objects moves through divided by the time taken to move through that angle.

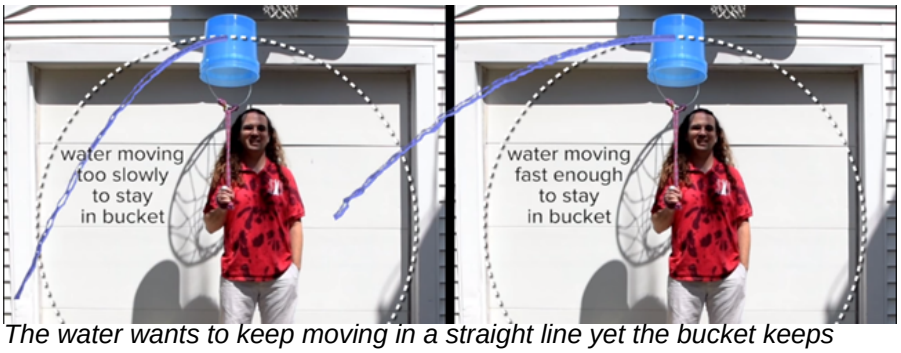
$$\omega = \frac{\theta}{t} = \frac{v}{r} = 2\pi f$$

To get from the first to the second, you would multiply both sides by the r to get speed then divide both sides by r. To get from the first to the last, you would replace θ with 2π and replace t (now the time period) with 1 / f.

---

46. What keeps water in a spinning bucket and how can the minimum velocity for which it can stay inside be found?

-The inertia of the water (its tendency to main its current state of motion).
-Water's speed = bucket's speed ∴ if the bucket is moving fast enough, the water will stay inside because its arc of projectile motion has a greater curvature than the circle in which its spinning.



The water wants to keep moving in a straight line yet the bucket keeps getting in the way.

- The minimum angular velocity required for it to stay in the bucket is when the weight of the water is the only force providing the centripetal force downwards…

$mg = mr\omega^2$

$\omega = \sqrt{(g/r)}$

---

47. What is required of the damping force?

Its magnitude to be directly proportional to the frequency of the oscillator.

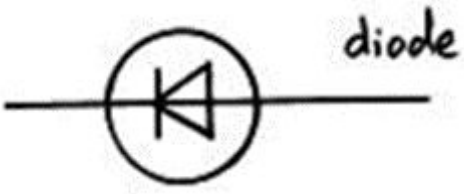
---

48. When does resonance occur? What is observed?

- When natural frequency = applied frequency.
- The largest amplitude for the system.

---

49. What is the circuit symbol of a diode?



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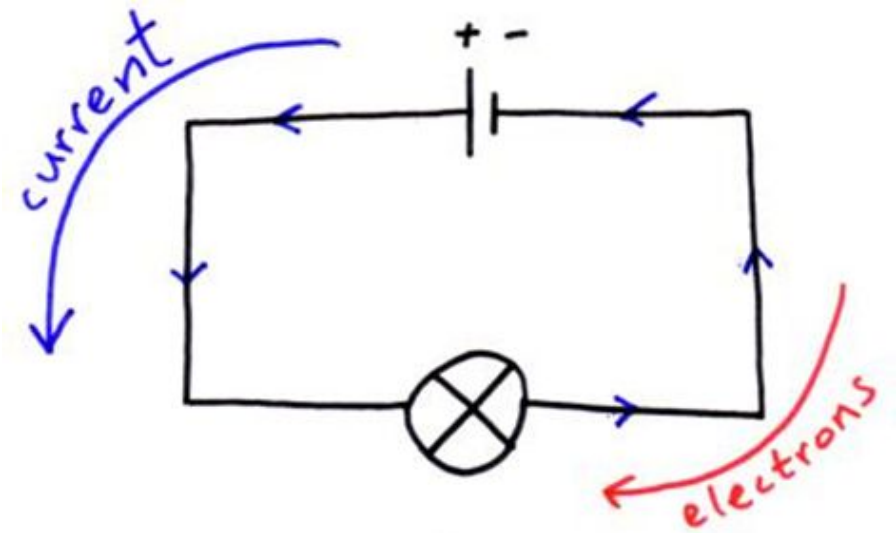
50. How does charge flow? And how does the the flow of current differ?

-Charge flows from - to + due to repulsion and attraction.
-Current flows opposite to charge by convention.



Always make conventional current on diagrams unless stated otherwise.

---

51. Give 4 properties of alpha particles

- Highly ionising due to size.
- Low penetration due to size.
- Charge of +2.
- Amu of ■4.

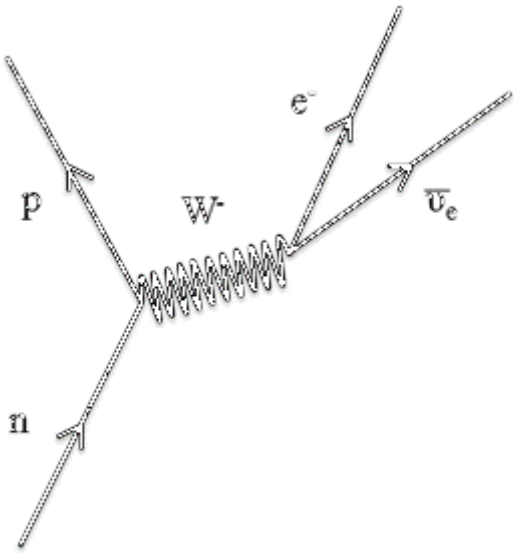
---

52. What are exchanges particles also known as?

Gauge bosons.

---

53. What is the Feynman Diagram for beta minus decay?



$$n \rightarrow p + e^- + \bar{\upsilon}_e$$

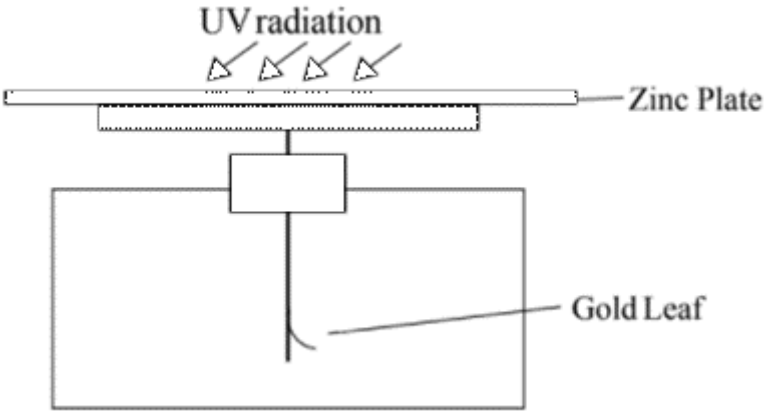
---

54. What do hadrons decay by?

Weak interaction.

---

55. What happens during the gold leaf experiment?



The zinc rod/plate is negatively charged ∴ gold leaf hangs tilted. Shining UV light causes it to discharge ∴ leaf falls down.

---

56. What happens in fluorescent lights?

1. Electrons are accelerated via a tube of mercury vapour atoms using a voltage, collide the electrons, transferring energy and thus exciting them.
2. Upon de-exciting, they emit UV photons of energy = difference in energy levels.
3. Fluorescent coating absorbs the UV photons, causes electrons to excite which upon de-exciting indirectly, emit visible photons.
The coating has to be on the inside of the glass as glass can absorb UV too.

---

57. What is a continuous spectrum?

An emission spectrum that consists of a continuum of wavelengths.

---

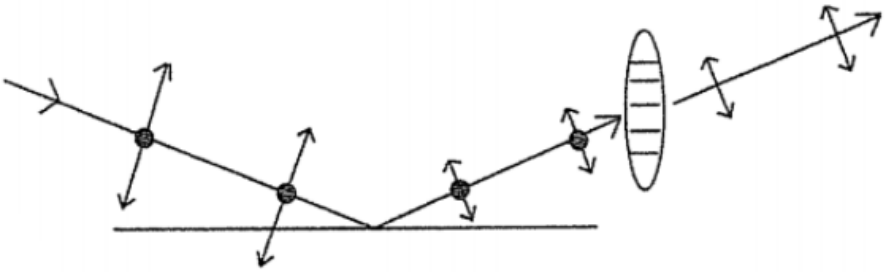
58. Why is light both a wave and particle?

As it undergoes things such as refraction, diffraction, and dispersion. Yet, also undergoes the photoelectric effect.

---

59. Give 3 uses of polaroid filters.

1. Polaroid glasses / sunglasses TO reduce glare.
2. Camera TO reduce glare/enhance image.
3. Stress analysis TO reveal areas of high/low stress.
For number 1. Light is reflected from a road surface is partially plane polarised. Polaroid sunglasses can stop this light getting in your eyes preventing a reflective road surface.



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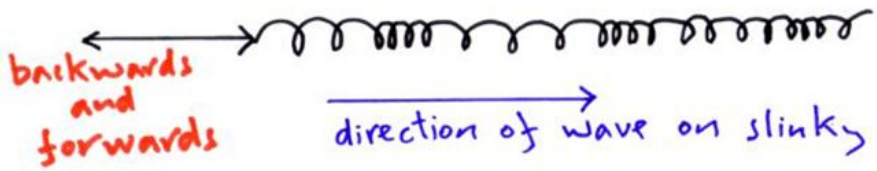
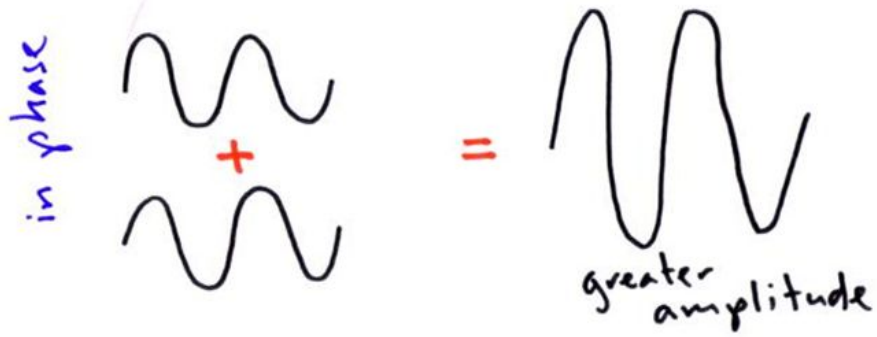
60. Describe the motion of longitudinal waves

The direction of **vibrations** are **parallel** to the **direction of energy propagation**.



61. When does constructive interference occur?

When **two waves some whole wavelength, nλ, apart** (otherwise known as in phase) superpose.



The waves constructively interfere to construct a wave of greater amplitude.

62. What wavelengths diffract more and why? (visible region)

Longer wavelengths because they have a lower frequency so less energy. The **more energy** a wave has, the **greater** its **tendency** to travel in a **straight line**.
Think of p = mv.

63. How can you work out the maximum order of a diffraction grating?

By setting θ to 90 and finding the lowest integer below n.

64. Why does 'the no. of photoelectrons per second depends on the intensity of the EM radiation' support the particle theory over the wave theory?

- Wave theory - greater frequency ⇒ more waves arriving per second ∴ more photoelectrons released ∴ intensity should have no effect.
- Particle theory - the no. of photons arriving per second depends on intensity ■ each photon has a fixed energy and one electron absorbs a photon in a one-to-one interaction.

65. What is Newton's First Law of Motion (Law of Inertia)?

"Every body continues at rest or with a constant **VELOCITY** unless acted upon by a resultant force."
VELOCITY is key as an object moving in a circle experiences a centripetal and is thus accelerating. Let's say you had a cup on a table, although it looks stationary, considering the Earth/Table perspective, it isn't as it's weight is slightly greater than the normal force as it's experiencing a centripetal force due to the Earth's rotation. However, we assume they're the same.

66. What is the principle of moments?

“For any system **IN EQUILIBRIUM**, sum of clockwise moments = sum of anticlockwise moments.”

---

67. How can you find the centre of mass of an object?

1. Freely suspend an irregular shape from a clamp.
2. Dangle a plumb line from the point of suspension and wait for the object to come to rest.
3. Draw a line following the string of the plumb line.
4. Repeat steps 1 - 3 for another point.

The centre of mass is where both lines intersect.

---

68. What is impulse and how is it calculated?

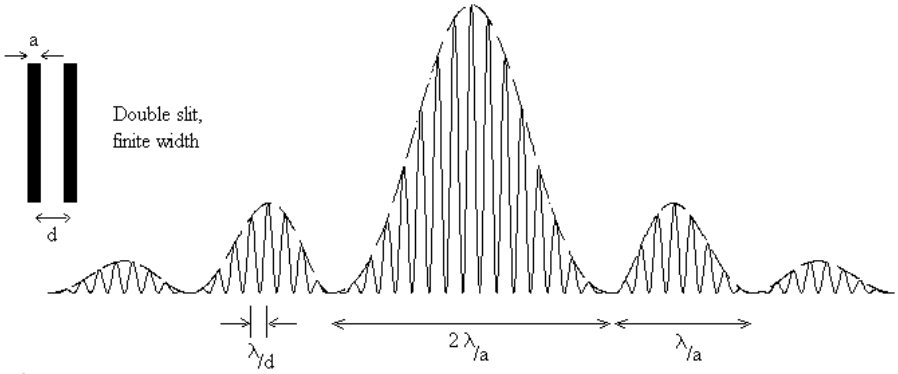
The change in momentum calculated by multiplying force by the time the force acts.

$$F\Delta t = \Delta(mv)$$

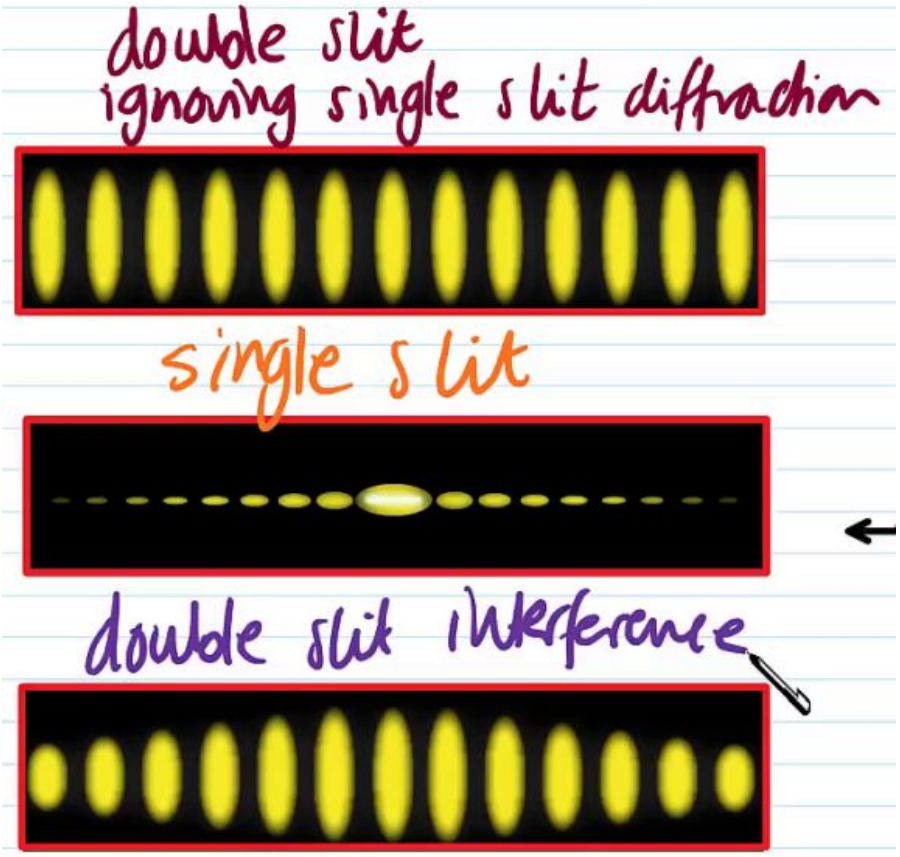
---

69. What appears on a screen under double slit diffraction?

An interference pattern enclosed by a single-slit envelope (of double the width in the centre).



Since...



70. What is the circuit symbol of a thermistor?

71. How does current work in series and why?

It is the **same wherever** you put the ammeter because it's a **rate**.

72. What affects the stability of the isotope and why?

No. of neutrons (i.e., the more neutrons, the less stable) ■ the strong nuclear force can no longer hold the nucleus together.

73. What is the minimum energy required of a photon to undergo pair production? What happens above this?

The total rest energies of the particles involved. For a particle-antiparticle pair, it would be:

$$hf_{min} = 2E_0 = 2mc^2$$

Above this, excess energy goes into kinetic energy.

---

74. What does the strong nuclear force / strong interaction do and what is it carried by?

- Holds electrostatically repelling nucleons together.
- Carried by gluons.

---

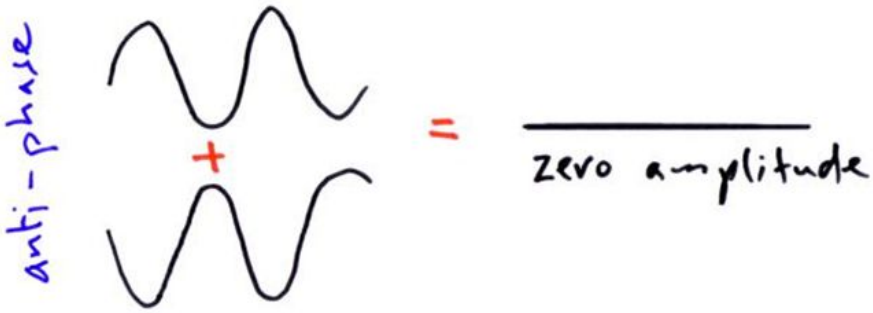
75. In what range does visible light lie?

400 nm to 700 nm.

---

76. When does maximum destructive interference occur?

When **two waves some one and a half-wavelength apart, (n + 1/2) x λ, apart** (otherwise completely-out-of-phase/anti-phase) superpose.

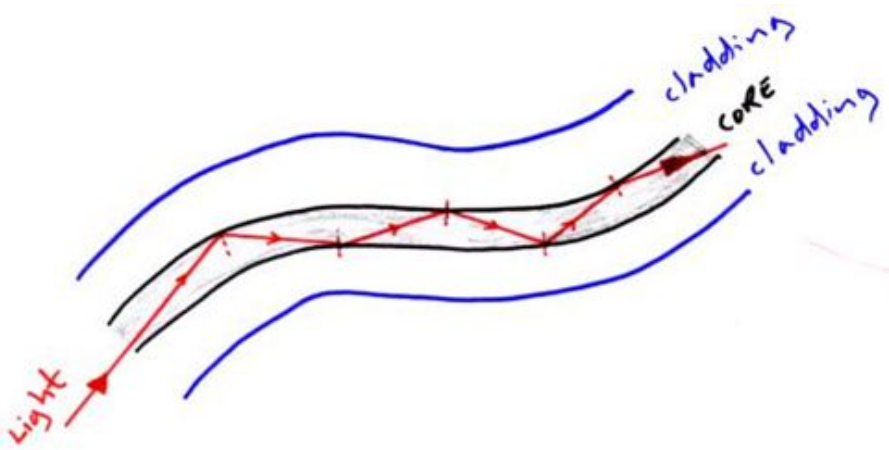


The waves destructively interfere to give a wave of zero amplitude.

---

77. Describe the structure of and the process of light travelling via an optical fibre

- A glass core surrounded by cladding of **lower refractive index** (1) to allow for TIR.
- Light enters, is slightly refracted at the start, is totally internally reflected when the **angle of incidence** ≥ **critical angle** (1).



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78. What is the 'breaking stress'/'ultimate tensile stress' and what can it represent?

-The maximum stress a material can handle before it breaks.
-Represents the strength of a material.

79. Sketch and label the 4 points of the stress-strain graph for a ductile material (such as copper)

-**L** - limit of proportionality, up to where force is ∝ extension.
-**E** - elastic limit.
-**Y** - yield point (where a small increase in force leads to a large increase in length).
-**B** - breaking point / breaking stress.

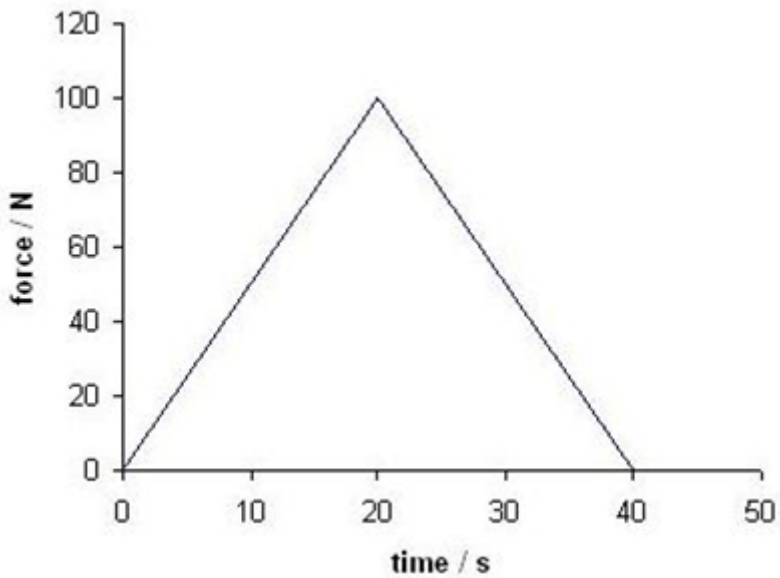
---

80. Why does 'electrons being emitted above f_0 despite intensity' support the particle theory over the wave theory?

- Wave theory - light consists of waves with energy ∝ intensity ∴ greater intensity should cause emission of photoelectrons regardless of frequency.
- Particle theory - light consists of photons with energy E = hf and the metal emits photoelectrons when $f \geq f_0$.
For the wave theory, imagine shining a lot of light onto one square metre.

---

81. Describe and explain the shape of the force-time graph of a steel ball bouncing off a surface



- This is analogous to jumping on a trampoline. The force the trampoline exerts back on you varies over time. At maximum deformation (the peak), the ball's direction changes.
- The area under the graph is the total change in momentum. It goes from, let's say, -5 $kgms^{-1}$ to 5 $kgms^{-1}$ thus half the graph is the initial momentum.

---

82. Describe the stages of a skydiver jumping out a plane

1. He initially accelerates at $9.81ms^{-2}$.
2. Air resistances increases as he falls faster and faster until he reaches terminal velocity.
3. When the parachute opens, the force of air resistance increases drastically causing deceleration.
4. Air resistance balances his weight again when he reaches terminal velocity again.
His weight remains constant throughout his dive.

---

83. What are force oscillators and what is their frequency called?

-Oscillators with a periodic driving force acting on it.
-Their frequency is the driving frequency.
Newton's Cradle as a whole is a free oscillator but the bobs themselves are forced oscillators.

---

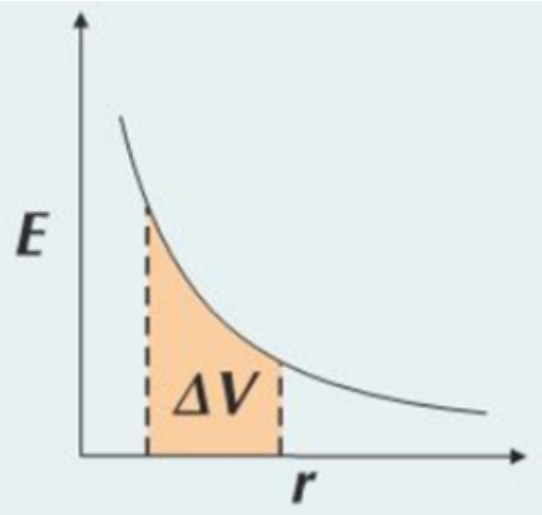
84. What is Electric Potential defined as (based on its equation)? How does it relate to a graph?

$$V = \frac{1}{4\pi\varepsilon_0}\frac{Q}{r}$$

Thus…

$$\Delta W = Q\Delta V$$

The work required to move a unit positive charge from infinity to a point against the electric field. Where infinity is defined as 0.
Its change is given by the area under a graph of electric field strength against radius.



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85. What is the difference between evaporation and boiling?

- Evaporation is going from liquid to gas.
- Boiling is the maximum temperature a liquid can stay as a liquid.

---

86. Define adiabatic

Energy being transferred without loss to surroundings.

---

87. What does closer field lines mean?

Greater flux density ∴ greater force on object here.

---

88. Why are transformers used?

As transmission over long distances is more efficient as high voltages than low ■ power is constant and current leads to heating.

---

89. What is mass defect?

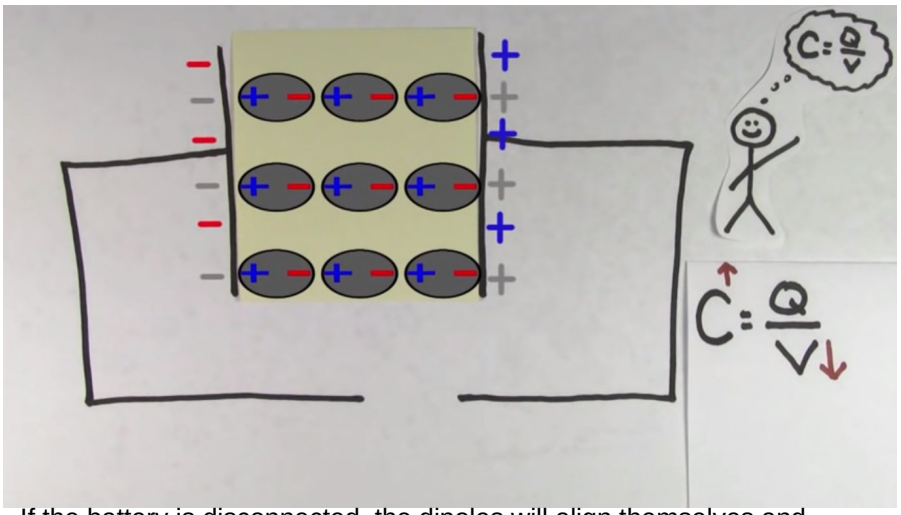
The difference between the mass of the separate nucleons added together and when all the nucleons are together in the nucleus.
The latter is less since it is more stable when it is together. When a nucleus is formed, this mass is released as energy.

90. How does a dielectric work? Why must work be done to remove it?

A non-conducting material (already polarised, like water, or not) is placed between the plates. The molecules align to the electric field (+ve pole to -ve plate) so to remove them, work must be done.

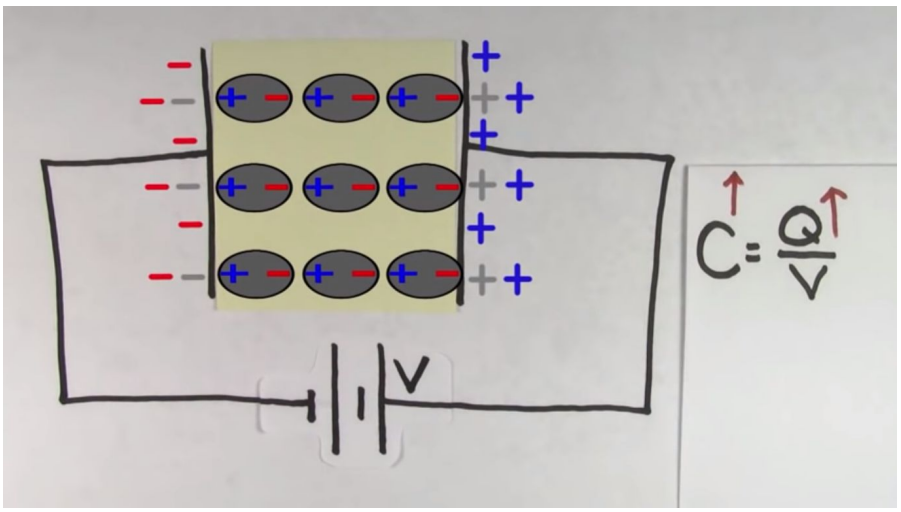
Two cases for inserting dielectrics:

1. Battery disconnected:



- If the battery is disconnected, the dipoles will align themselves and partially cancel some of the charges on the plates reducing the voltage thus increasing the capacitance.

2. Battery connected:

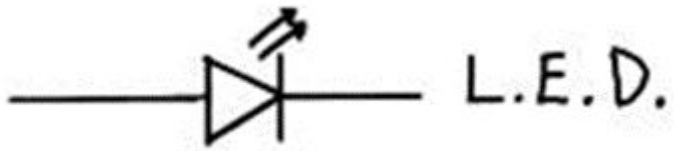


- If the battery is connected, the dipoles will again partially cancel some of the charge yet the battery will send in more charge to maintain the voltage thus increasing the capacitance.

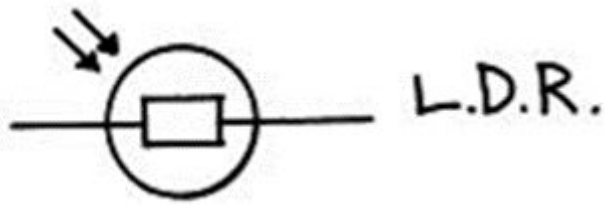
91. How do gas molecules exert pressure?

Molecules collide with walls (1) walls exert force on molecules (1) molecule exerts equal and opposite force on walls (1) creating pressure (1)

92. What is the circuit symbol of a L.E.D?



93. What is the circuit symbol of a L.D.R?



94. Why are voltmeters used in parallel?

They have a **very high resistance** ■ you want as **little current** to pass through them, you put them in parallel.
You still need a tiny bit of current to calculate voltage.

95. When is maximum power delivered to the load?

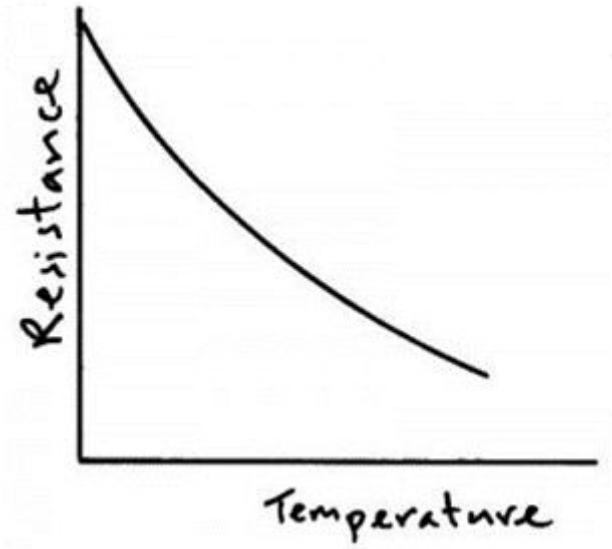
When load resistance = internal resistance.

96. What applications do diodes have?

To protect components in circuits.

97. What key feature does a thermistor have and what does this mean and why?

Negative temperature coefficient (NTC) ⇒ its **resistance decreases** (1) as its **temperature increases** (1) as **electrons are released** (1).



98. How does resistance work in series and why?

Total resistance = sum of all individual resistances ■ $V_T = V_1 + V_2 \Rightarrow IR_T = IR_1 + IR_2 \Rightarrow R_T = R_1 + R_2$.

99. How does p.d. work in parallel and why?

Same across all lines ■ it is merely the **energy transferred per coulomb of charge** which is the same for each coulomb.

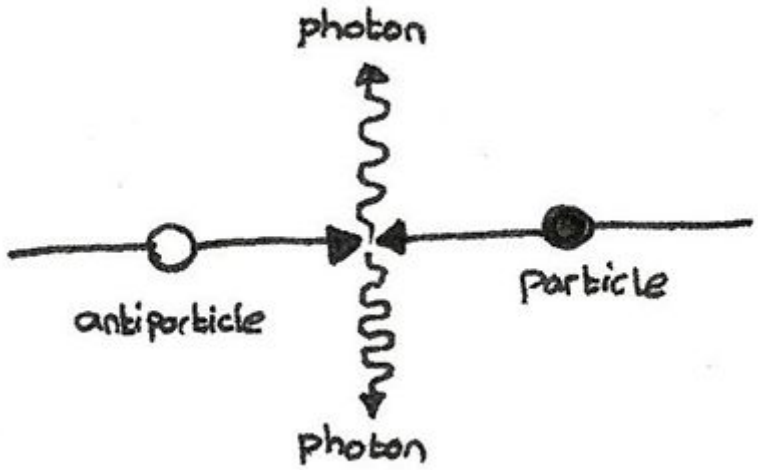
100. What is Kirchhoff's Second Law?

"In any loop (path) around a circuit, the sum of the e.m.f's = the sum of the p.d.'s."
Second for **S**um.

---

101. What is annihilation?

When a particle and its antiparticle meet and annihilate converting their mass into energy in the form of photons moving in opposite directions to conserve momentum.



These particles are moving in opposite directions to conserve momentum.

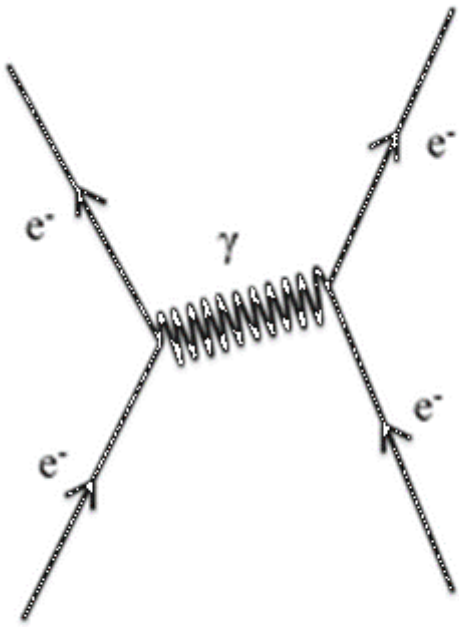
---

102. What particles are usually produced from pair production and why?

Electron-positron pairs due to their relatively low rest mass.

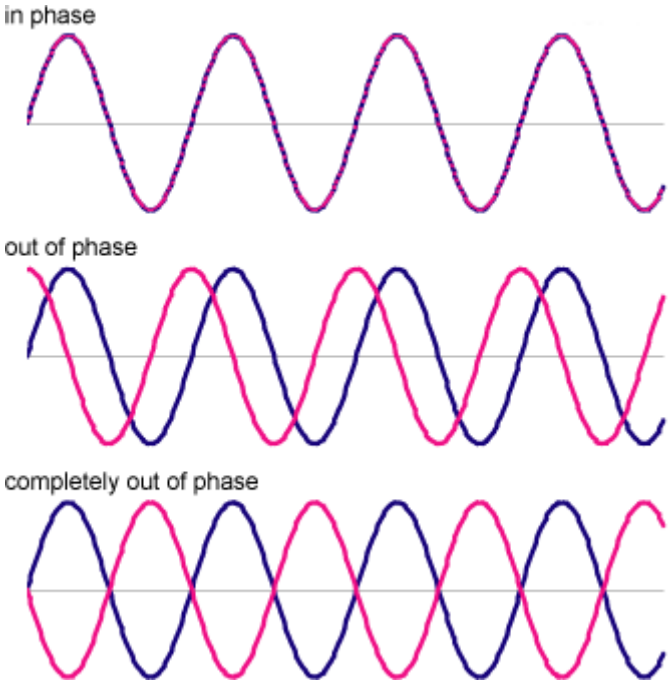
---

103. What is the Feynman Diagram for the repulsion between electrons?



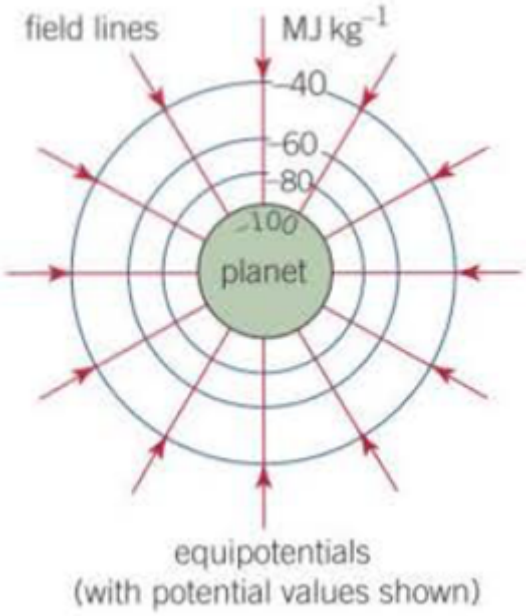
$$e^- + e^- \rightarrow e^- + e^-$$

Two electrons exchange a virtual photon as they repel.

104.	Define baryon and give the structure of 2 baryons	- A hadron consisting of 3 quarks. - Proton with uud and neutron with udd.
105.	What is a lepton?	A particle that **ISN'T** subject to strong interaction.
106.	What ‘in phase’ and ‘in antiphase’ mean?	- **In phase:** peaks line up with peaks and troughs with troughs. - **In antiphase:** peaks line up with troughs and vice versa. 
107.	What is the distance between two nodes AND a node and antinode?	- Two nodes is ½ λ. - Node and antinode is ¼ λ.
108.	Which 'types of diffraction' occur as the gap size varies?	- When **aperture size = wavelength**, **maximum** diffraction. - When **aperture size << wavelength**, wave **reflects back**. - When **aperture size >> wavelength**, **diffraction** occurs at **edges**.
109.	What is monochromatic light?	Light of a single frequency/wavelength.
110.	What makes the analysis of a diffraction grating is better than Young’s Double Slit?	- It's easier to measure the fringe separation as more light passes through leading to brighter and sharper fringes. - It doesn't rely on small angle approximation (thus you have to find the angle of each order yourself).
111.	What is ‘not present’ at a node and why?	Energy as it has zero amplitude.

112. What is the first, second, and third harmonics also known as and how are they related?	- First - fundamental mode. - Second - first overtone (double the frequency of first, half the wavelength). - Third - second overtone (triple the frequency of first, a third the wavelength).
113. What is the elastic limit?	The point beyond which a material is permanently deformed.
114. What is mechanical energy?	Energy due to the movement or position of an object (kinetic or potential).
115. What is a field?	An area of space where mass/charge feels a non-contact force.
116. What is Gravitational Potential defined as and why is it negative? $V = \frac{-GM}{r}$	- The work done per unit mass (1) in moving from infinity to that point (1). - It is negative because... At infinity, the gravitional potential is ZERO. Gravity is attractive, so field (system) must have done work on mass moving it to that point so the field (system) has lost potential. *This equation is the case as its the area underneath the force-distance graph:* $W = \int_{\infty}^{r} F\,dr$ $= Gm_1m_2 \int_{\infty}^{r} \frac{1}{r^2}\,dr$ $= Gm_1m_2\left[-\frac{1}{r}\right]$ $E_p = -\frac{Gm_1m_2}{r}$

117. What is an equipotential? How as they positioned?

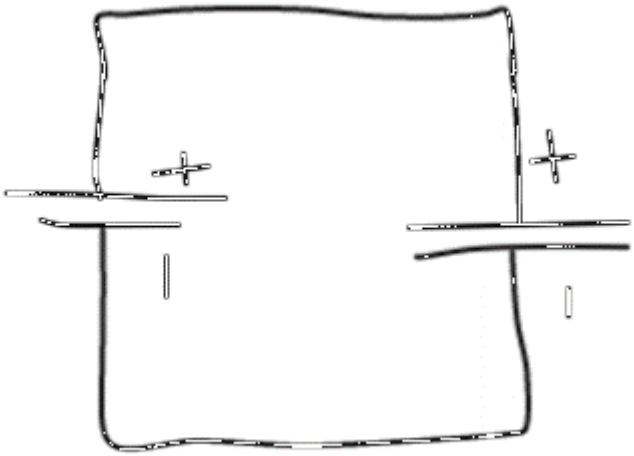


- Lines (2D) / surface (3D) along which gravitional potential / electric potential is constant (no work done when moving along it).
- Is perpendicular for field lines.
- Equal increases are spaced further apart as the field strength decreases so you can move further with the same work done.

---

118. How does a capacitor become charged?

-Electrons move from the cell to the capacitor ∴ making one side negatively charged.
-This side repels electrons on the other side making that positive.



No current ever actually passes across the parallel plates.

---

119. What is the time constant of a capacitor defined as and what does it affect?

$$T = RC$$

-Where R is the resistance of the circuit and C is the capacitance of the capacitor.
-Increasing T increases the time taken to charge and discharge so current flows for a longer time.

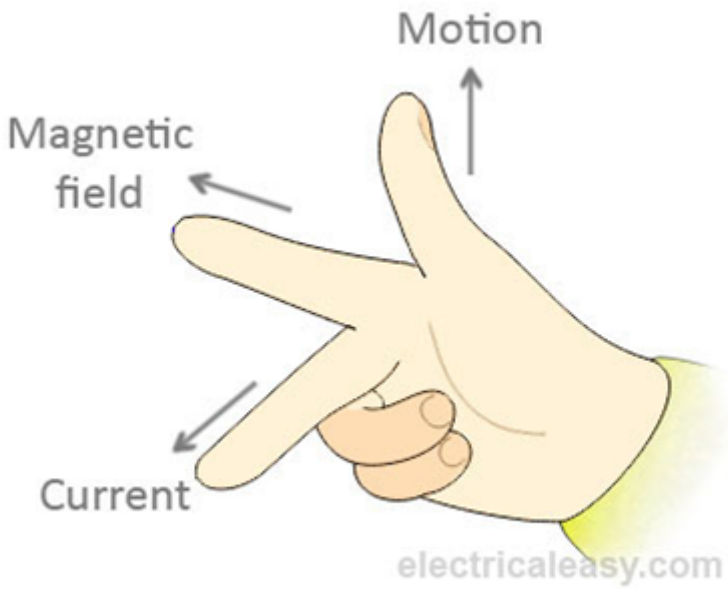
120. What is Electric Field Strength?

$$E = \frac{F}{Q}$$

$$E = \frac{1}{4\pi\varepsilon_0}\frac{Q}{r^2}$$

The force per unit positive charge (thus, its direction is the direction a positive charge would move).

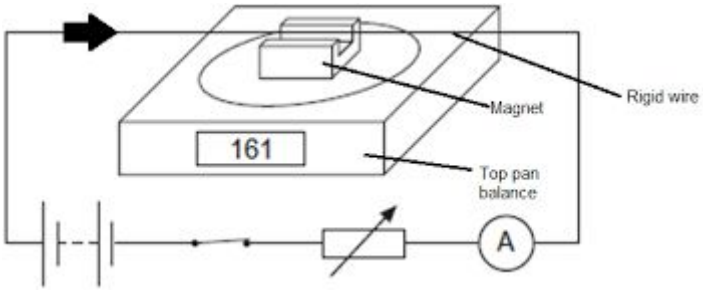
121. What is Fleming's Right hand rule? What is it used for?



- Thumb = thrust / force.
- First finger = field (going north to south).
- Second finger = conventional current
- Used for generators (gene**RIGHT**ors).
- Used to determine the direction of current in the **dynamo effect** (where force and field are known).

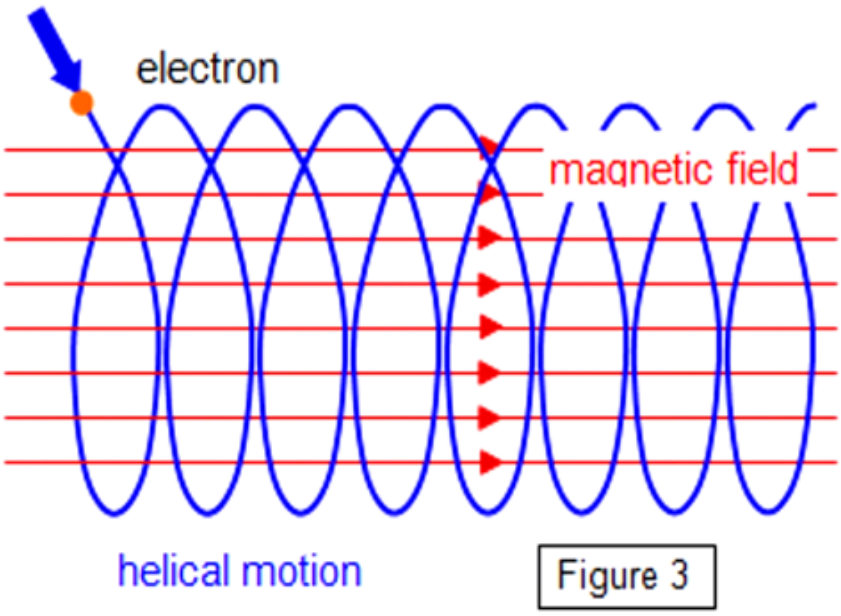
122. How can the magnetic flux density be determined?

1.Place magnet on balance.
2.Clamp wire passing through the magnet.
3.With no current passing through, set balance to zero.
●We know mg = BIl. If we measure mass of 0.05 g, we know current and length then we work out the magnetic flux density.



123. How does Fleming's Left Hand Rule apply to a charge moving in a magnetic field?

The force is perpendicular to the direction of motion ⇒ circular motion.
You have to the careful, current is conventional current - the direction in which a positive charge moves.
And only one component of velocity will be affect (the component within the perpendicular plane).



124. What is an Eddy Current? Where does it come from?

A localized electric current induced in a conductor by a varying magnetic field.

Example:

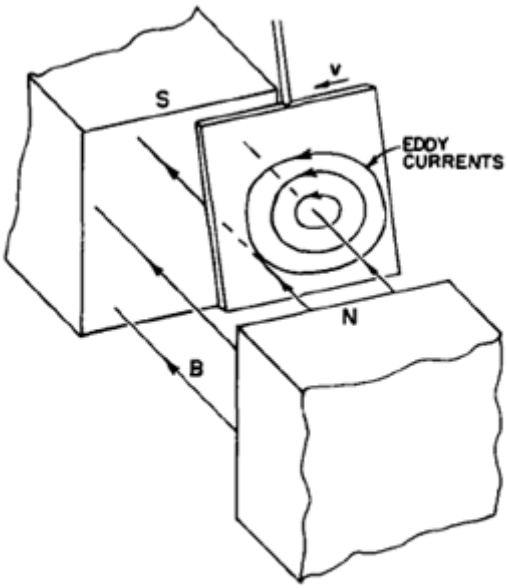


Fig. 16–11. The eddy currents in the copper pendulum.

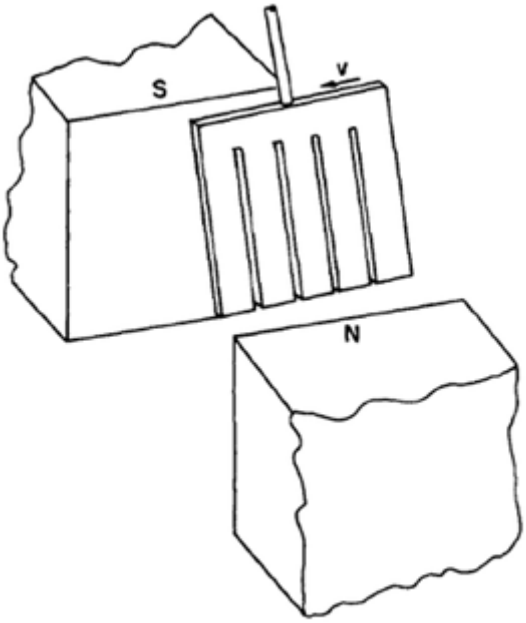


Fig. 16–12. Eddy-current effects are drastically reduced by cutting slots in the plate.

●The left pendulum is made of a complete sheet of copper allowing eddy currents to flow generating a magnetic field which opposes the motion of the pendulum thus slowing it down.

●The right pendulum has slits, reducing possibility of eddy currents thus less opposition to motion. This one will swing for longer.

● The right one has a higher resistance so smaller Eddy Currents.

125. How and why is radioactivity used in sterilization?

- Gamma rays can be used to sterilize medical instruments and keep food fresh for longer.
- As it's the most penetrating so can irradiate all sides.

---

126. What moderators are used in nuclear fission and what 3/4 requirements do these moderators fulfil?

●Water or graphite.
1.Small/light nuclei.
2.Shouldn't be radioactive when bombarded with neutrons.
3.If solid (like graphite), requires high melting point.
4.Available in large amounts.

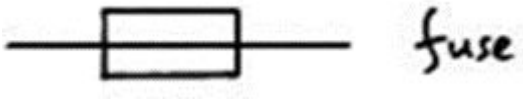
---

127. What is critical mass and supercritical mass under nuclear physics?

Critical mass:
■The minimum mass required for a chain reaction be self-sustaining, continuing at its own steady rate.
■Anything less and the reaction peters out.
■On average, one neutron from each fission will cause a further fission.
Supercritical mass:
■Used in nuclear reactors and atomic bombs.
■Several new fissions follow each fission.
■The rate is then controlled using control rods in nuclear reactors.
Note that not all neutrons will go on to cause fission, some will escape into the surroundings.

---

128. What is the circuit symbol of a fuse?



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129. What can resistance be described as?

How hard it is for current to flow through a component.
It being R = V/I means it's a measure of how much current you get for a particular p.d.

---

130. What is Ohm's Law?

"Provided physical conditions remain constant, the current via an ohmic conductor is directly proportional to the p.d. across it."
This means that doubling the p.d. doubles the current (as the particles have more energy so move faster).

---

131. What is a superconductor defined as?

A material with **ZERO RESISTANCE** at or below its **critical temperature**.

---

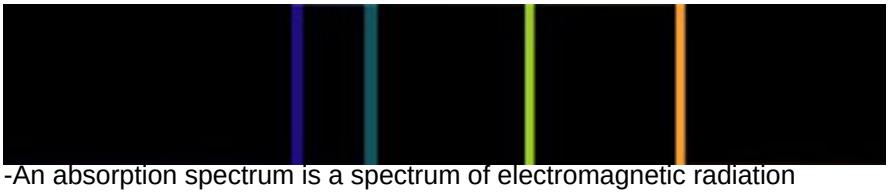
132. What is a potential divider?

A circuit that uses **two or more resistors** in series to supply a **variable p.d.**

---

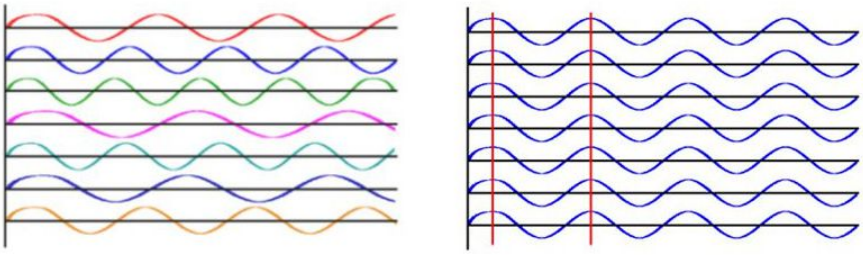
133. What is the equation used for annihilation and why?

$$2hf_{min} = 2E_0 = 2mc^2$$
As two particles make two photons.

134.	What do kaons decay into and by what?	Pions by weak interaction.
135.	What are the 6 leptons?	Electrons, muons, tauons, electron neutrino, muon neutrino, and tauon neutrino.
136.	What is de-excitation?	When an **electron moves** from a **higher energy level** to a **lower energy level** whilst **emitting a photon** of fixed frequency.
137.	What is an emission spectrum and an absorption spectrum?	-An emission spectrum is a spectrum of electromagnetic radiation emitted from electrons de-exciting:  -An absorption spectrum is a spectrum of electromagnetic radiation transmitted via a substance with dark vertical lines corresponding to waves absorbed.
138.	What is frequency (in terms of waves)?	The **number** of **waves** passing through a point **each second** (measured in Hz or s^{-1}).
139.	What is time period in terms of waves?	The time taken for one complete wavelength to pass a point.

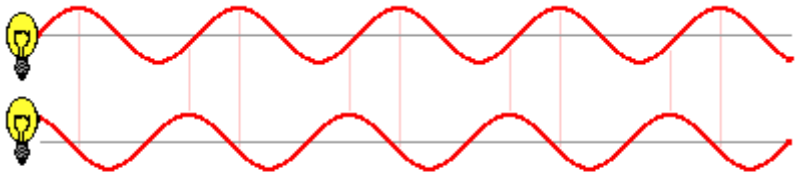
140. When are two waves coherent?

When they have **CONSTANT PHASE DIFFERENCE** and **SAME WAVELENGTH**.



Incoherent light waves Coherent light waves

Or...



These two waves are coherent - they have a phase difference which is constant over time.

Yet the 2nd image isn't required by AQA.

---

141. What is the displacement at the nodes and antinodes of a stationary wave and why?

-At the **node**, no displacement because **maximum destructive interference** occurs.
-At the **antinode**, maximum displacement because **constructive interference** occurs.

Less destructive interference occurs as you move towards the rest position. This is partial destructive interference.

---

142. How does the mass of a gauge boson affect the range of its force?

The greater its mass, the short the range of the force.
W bosons have a mass 100x of a proton ∴ require a lot of energy ∴ can only exist for little time ∴ cannot travel far. Whereas photons with zero mass have infinite range.

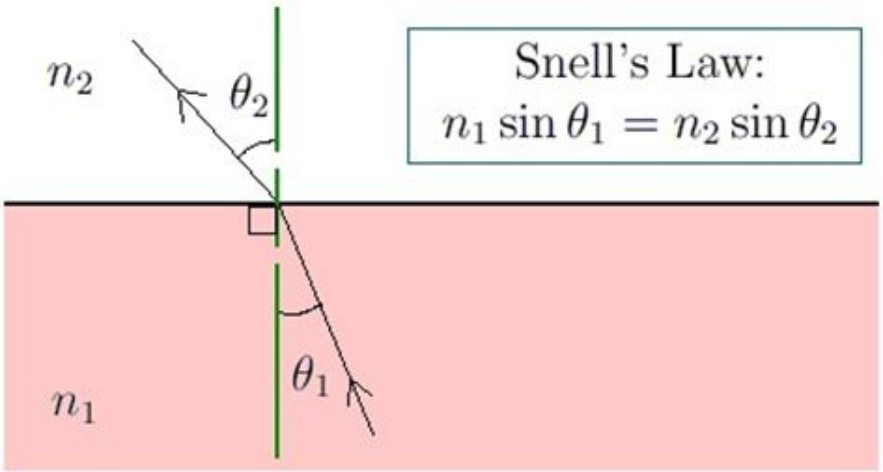
---

143. What structure is required for electron diffraction and why?

- Crystalline structure.
- The gaps between atoms ≅ De Broglie wavelength of electron for maximum diffraction to occur.

---

144. What is Snell's Law?



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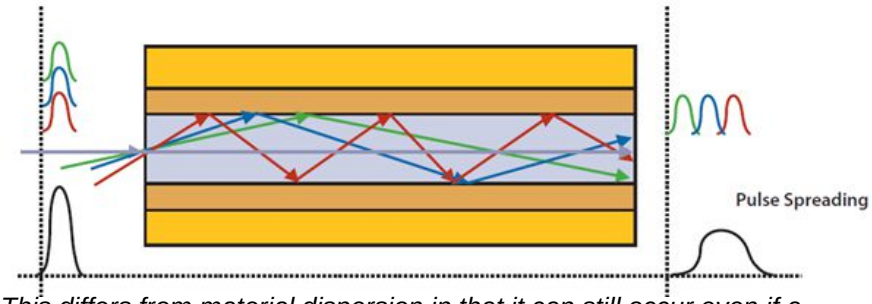
145. Describe multimode/multipath dispersion and what this leads to

- **Different wavelengths enter** and are refracted to **slightly different angles**.
- They **follow slightly different paths** (some taking longer than others due to more reflections) thus **leaving at different times**.
- This leads to **pulse broadening**.

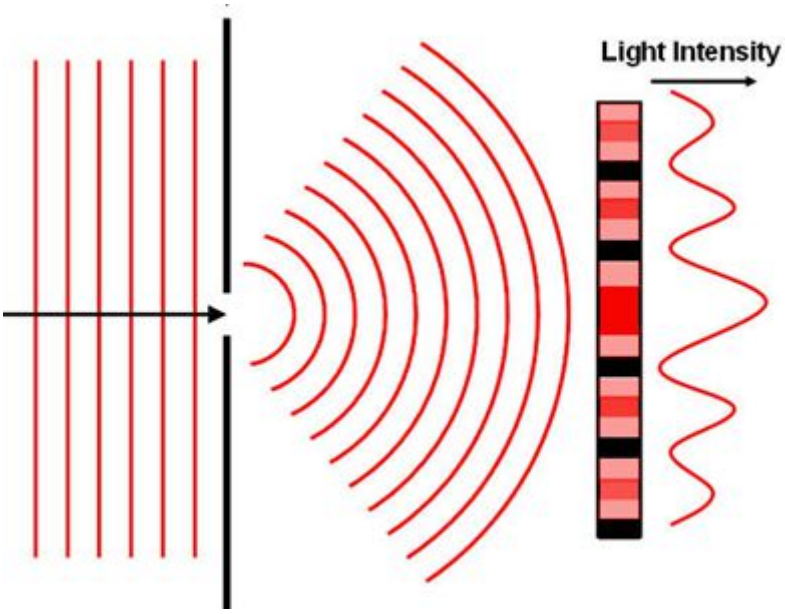


This differs from material dispersion in that it can still occur even if a monochromatic source of light is used.

---

146. Describe what appears on the screen under single slit diffraction of monochromatic light

-A **diffraction pattern** of alternating light and dark fringes.
-The **central fringe** is **brighter** and **double in size**.
-The **fringes** get **dimmer** as you move from the centre.



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147. What is Hooke's Law?

Provided the limit of proportionality is not exceeded, the extension of a spring/wire $\propto$ the force applied.
The graph of load against extension of a spring obeying Hooke's Law will have a line of constant gradient passing via the origin. These are two features.

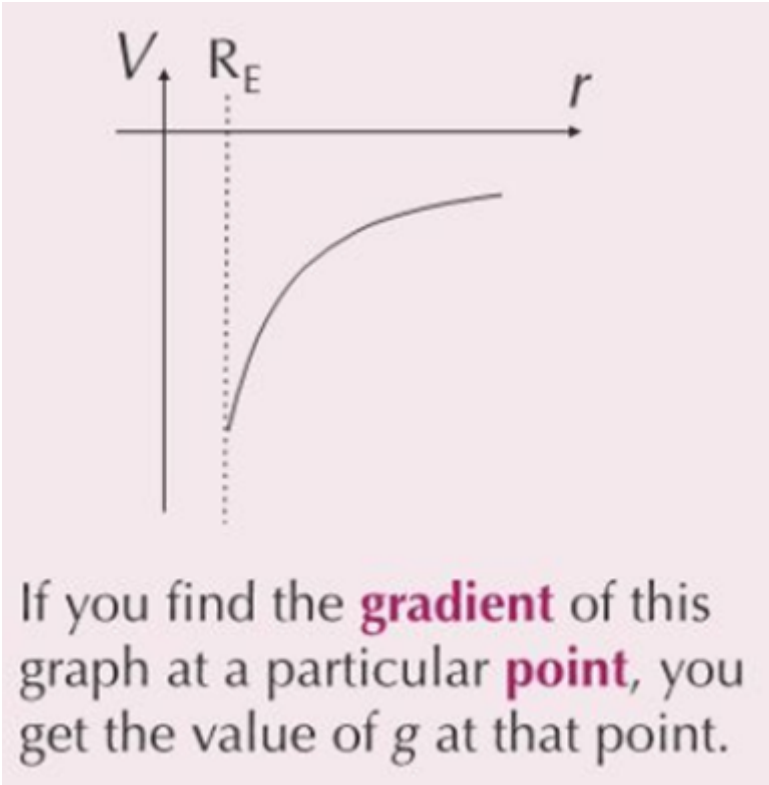
---

148. Why do standing/stationary waves only form under specific frequencies?

As there has to be a node/antinode on either side $\therefore$ you need a wavelength that is a specific fraction of the length of the wire.

---

149. What does the gravitational potential against distance graph look like?



If you find the gradient at a point, you get the value of g as $g=-\Delta V/\Delta r$ where the negative sign shows it acting in the opposite direction to gravitational potential.

---

150. How is polarisation used in transmission and reception?

- TV signal transmitted horizontally or vertically and your antenna should match the signal polarisation.
- Antenna in a given area have the same polarisation to prevent interference from nearby stations (oppositely polarised).

---

151. What is the work done on a gas given by?

$W = P \times \Delta V$
- Work Done = Pressure x Change in Volume

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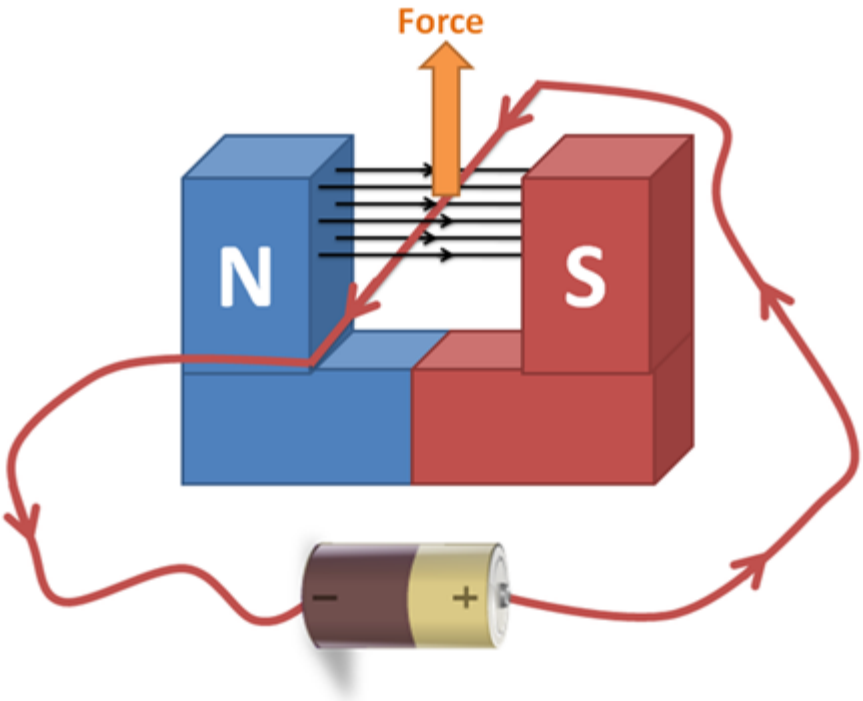
152. What is the motor effect?

The force exerted on a current-carrying conductor in a magnetic field.

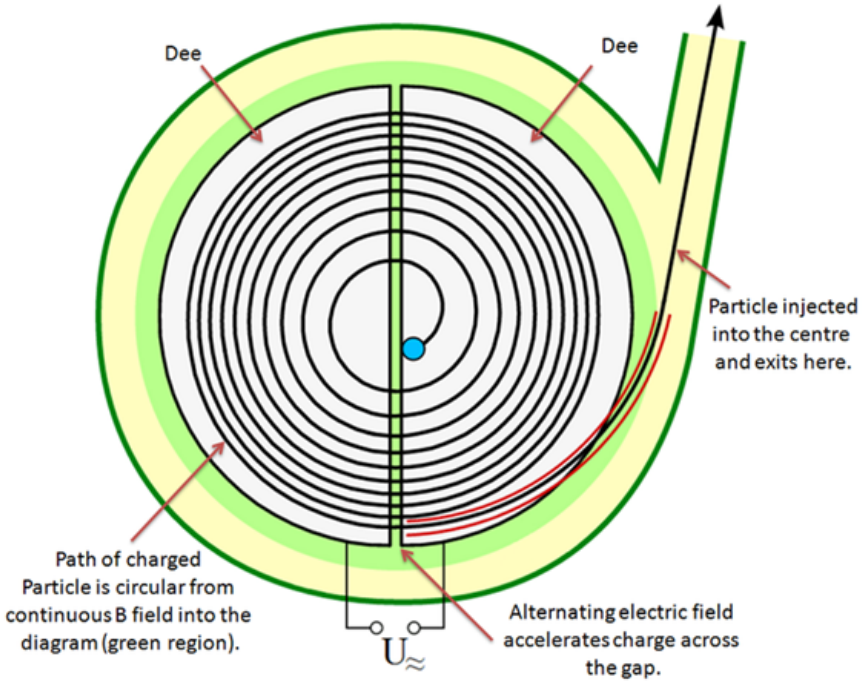


153. What is a cyclotron used to do?

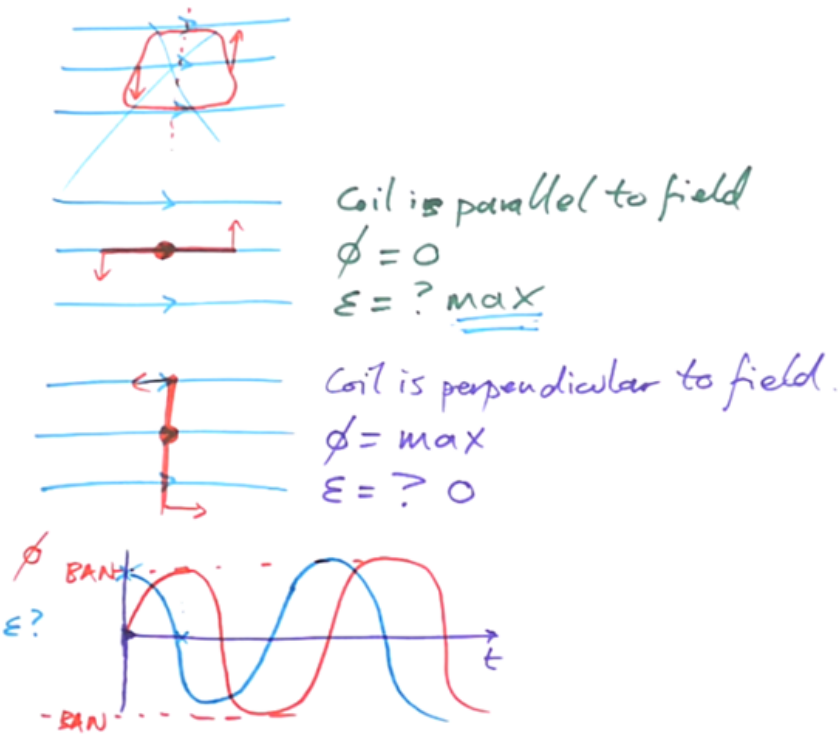
Create beams of high energy protons / electrons for particle accelerators.

154. How does a cyclotron work?

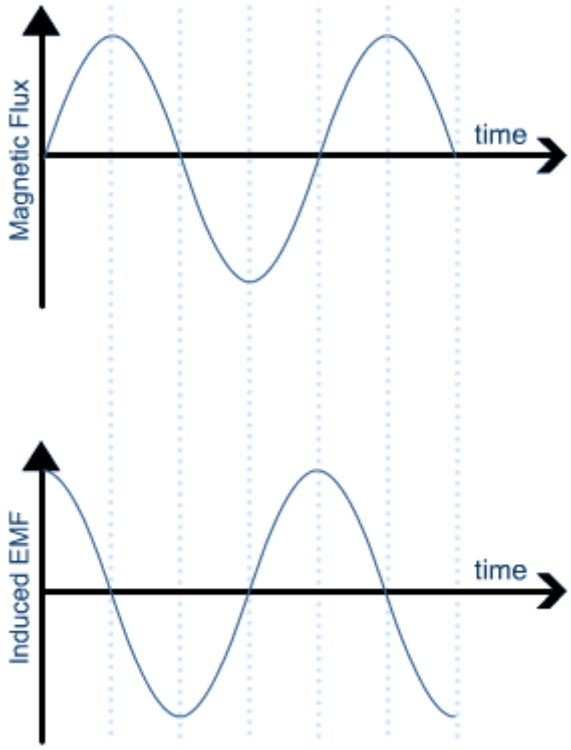
The electric field flips frequently is such that each time a particle reaches exits a ‘dee’ it is accelerated.



155. When is induced emf a maximum in a coil?



Consider the graph carefully here. It is shown better below:

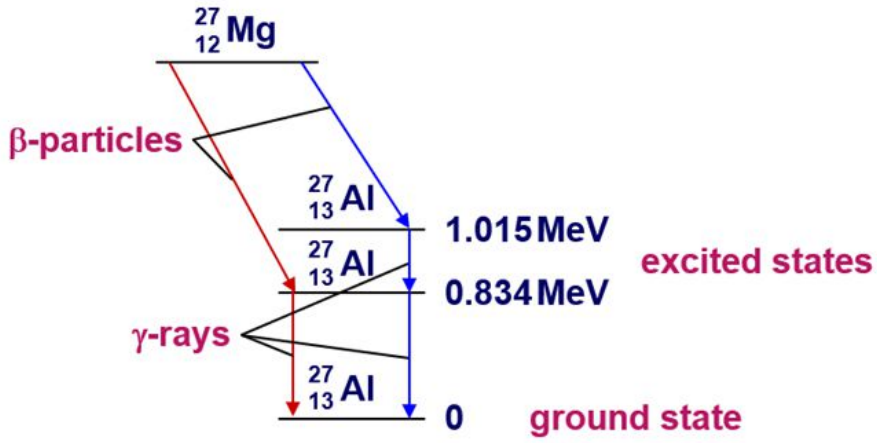


156. How are transformers designed to be efficient? Why?

1.Low-resistance cable windings to reduce heating effect of current.
2.Laminated core consisting of layers of iron separated by layers of insulator to reduce eddy currents (making magnetic flux as high as possible and reducing heating).
3.'Soft iron' core which is easily magnetised and demagnetised to reduce power wasted through repeated magnetisation and demagnetisation.
4. Having high resistivity metal to **REDUCE** Eddy Currents.

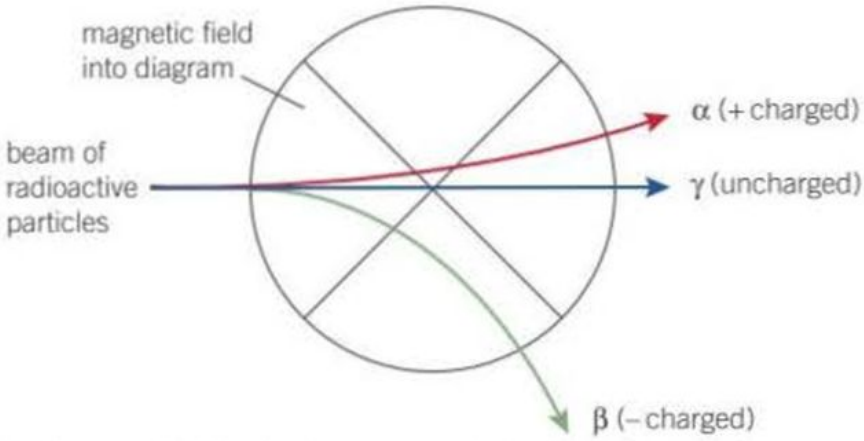
157. How are metastable states formed? What radiation is emitted and how?

●When a nucleus decays into its daughter nucleis, it is in an **excited state**.
●**Gamma ray** photos are emitted upon the nucleus de-excited (due to the large gap between energy levels).
●**IF ELECTRON CAPTURE**, electron de-excites to fill vacant space left by inner electrons emitting **gamma rays**.



158. How do α, β and γ radiation vary in simple electric and magnetic fields?

●α particle and β particle:
- Deflected in opposite directions.
- α particles deflected less than β particle if travelling at same speed.
●γ wave - no charge so unaffected.

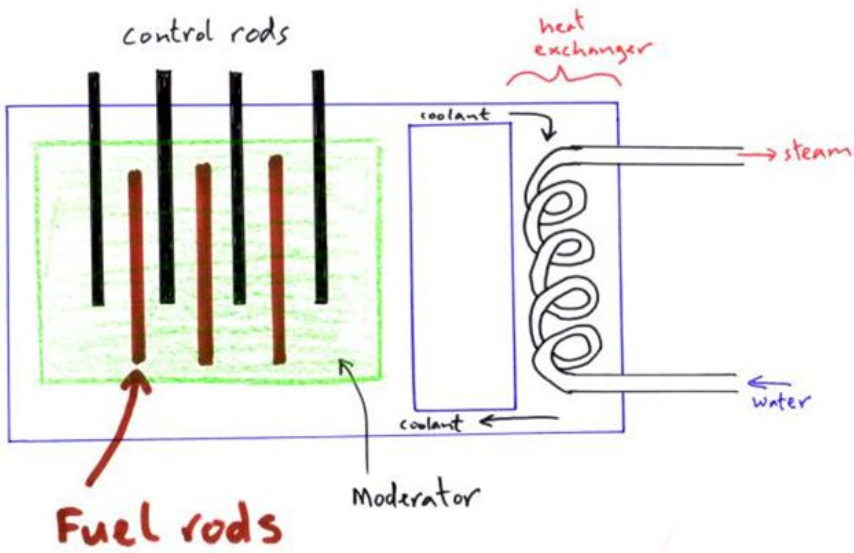


This is very similar for electric fields.

159. How is radioactivity used in radiotherapy-cancer treatment?

Uses gamma sources to attack cancerous cell.
It relies on cancerous cells being affected by radiation more than others.

160. Draw and describe a nuclear reactor (5 parts)



1.Fuel rods - contain the uranium used in fission.
2.Moderator - slows down fast-moving neutrons (through elastic collisions) into slow neutrons called thermal neutrons so they can be absorbed.
3.Control rods - move in and out of the core to slow down / speed up the rate of fission.
4.Coolant - cools down the core by transferring the energy to the water in the heat exchanger.
5.Heat exchanger - water turns into steam which turns a turbine connected to a generator.
The coolant may be water, despite this, there is always water in the heat exchanger. It still runs when the reactor isn't on since nuclei as still decaying.

---

161. What material is used for control rods and what factors affect it?

Boron since…
- It absorbs neutrons.
- Has a high melting point.

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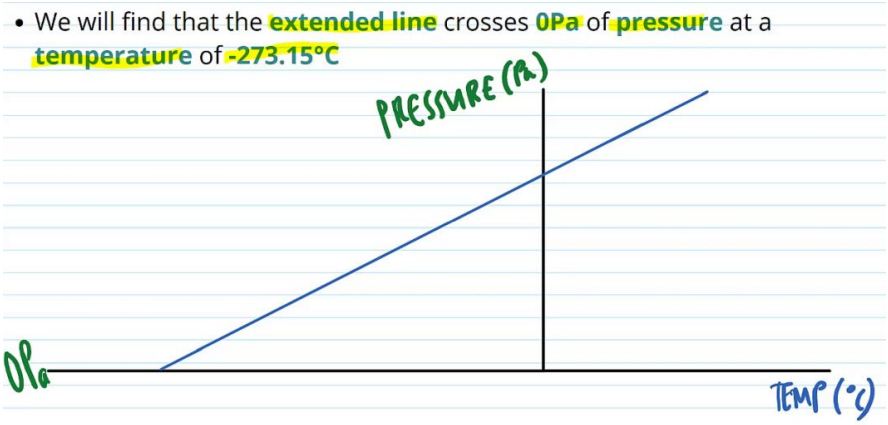
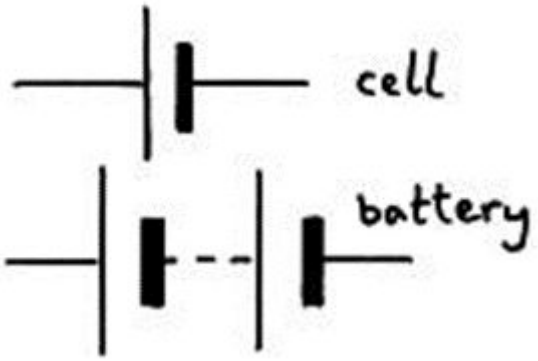
162. Draw the graph of temperature against (in Celsius) pressure under Pressure Law

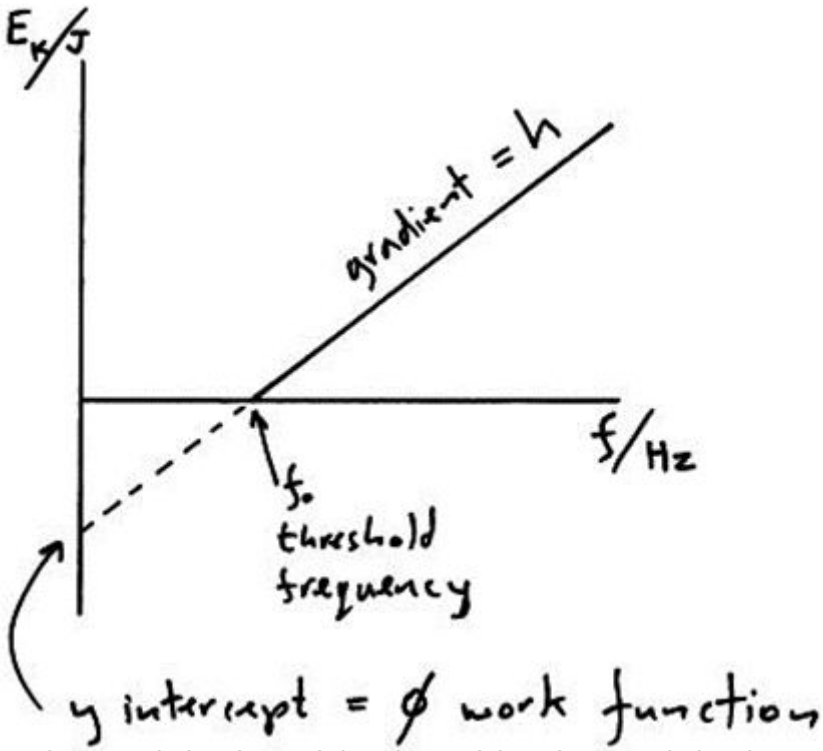


163.	Discuss an experiment that can be performed using a gas which would enable you to explain absolute zero and determine its value	1. Constant mass of any gas (or trapped gas) **AND** constant volume. 2. Record pressure for range of temperatures. 3. Adjust temperature using temperature bath or oven. 4. Draw a graph of pressure against temperature that is linear (eg, P = nRT/V so P = kT) 5. Use results of P v. T to extrapolate to lower temperatures which have zero pressure **which is -273 C**.
164.	Which type of radiation is used in medical tracers and why?	Gamma rays as they are the most penetrating and least ionising.
165.	When is an emf induced? (with example)	- When there is a change in magnetic flux (linkage). - Eg, when a metallic conductor cuts flux lines (you have a change in area per unit time)
166.	What is the circuit symbol of a cell/battery?	
167.	What is current?	- The rate of the flow of charge. - 1 A is 1 C flowing via a point every second.
168.	What is potential difference and hence 1 V?	- The energy transferred (**work done**) **per unit of charge**. - 1 V is 1 J transferred per coulomb of charge.
169.	How does resistance vary with dimensions and why?	- It **increases with length** ■ charge carriers have **more to flow through**. - It **decreases with area** ■ charge carriers have **more options** in taking the path of **least resistance**.
170.	What does a diode do and how?	It **only allows current** to flow in the **forward direction** by having a very high resistance in the backwards direction.
171.	What are the 3 key points of Feynman Diagrams?	-The only axis is time. -Momentum is preserved at each vertex. -The gauge boson must be drawn as a wiggly line.
172.	What hadrons and leptons don't decay and why?	Protons, electrons, and neutrinos ■ they're the most stable with the least rest energy.

173. Why do photoelectron kinetic energies vary to a maximum?

- $E_{k\ (max)} = hf - \varphi$.
- Each photon's energy is the same (due to frequency) and more energy required to move e^-'s further from surface due to more attraction ∴ less remaining for K_E.

174. How does the photoelectric effect equation look when plotted as a line?



The y-intercept being the work function and the x-intercept being the threshold frequency.

175. What happens on the quark-level of beta minus decay?

- A down quark in the nuclide decays into up quark whilst emitting a W^- boson (1).
- The W^- boson decays into a beta minus particle and anti electron neutrino (1).

176. What is the refractive index of air?

Approximately one.

177. Give 3 reasons for why cladding is useful for optical fibres

1)Protects the core.
2)Prevents cross-talk.
3)Increases data transfer rate.

178. What does absorption cause a loss of for a wave?

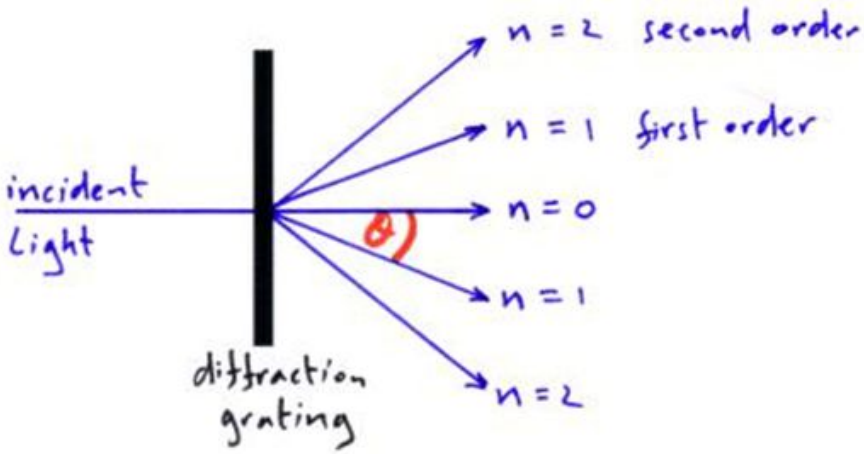
A loss in amplitude/intensity.

179. What is intensity?

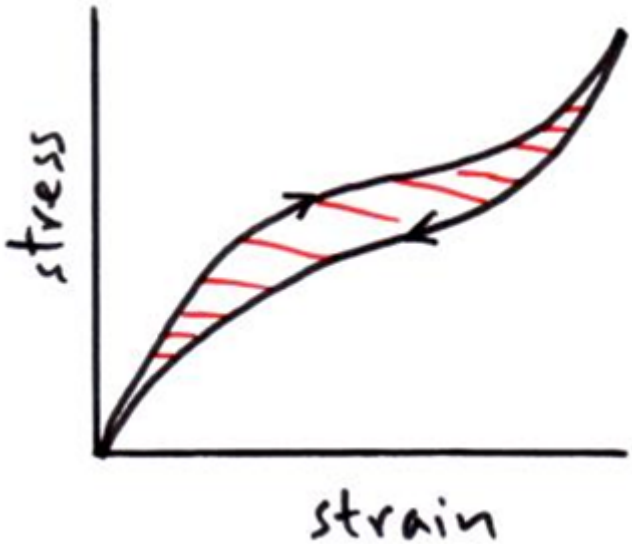
Power per unit area (W/m^2).

180. What is a diffraction grating? What does it do?

A glass piece with **closely spaced parallel lines** which splits light into a spectra.



181. Sketch and describe the loading-unloading stress-strain graph of rubber



-The difference in area is the **energy lost per unit volume** due to internal friction.
-This is called a hysteresis loop.
You know this shape because when pulling a rubber band, it starts off hard to pull, becomes easier, then becomes harder again.

182. What is Newton's Third Law of Motion? (and what is important here?)

- "For every action, there is an equal and opposite reaction."
- The forces of are of same type.
This is a result of electrostatic repulsion between electrons. When you "touch" stuff, you're not actually touching it. Your hand is slightly hovering above it.

183. What is the Centre of Mass and Centre of Gravity?

- Centre of mass is the point where all the mass seems to be concentrated.
- Centre of gravity is the point where all the weight seems to be concentrated.
In a uniform gravitational field, both are in the same place.

184. When is Hooke's Law used and when is Young's Modulus used?

- Hooke's Law is for specific devices (e.g., springs or some length of wire).
- Young's Modulus is used for materials (as it's independent of dimensions).

185. What happens in the 2 cases of charging a capacitor then increasing the separation?

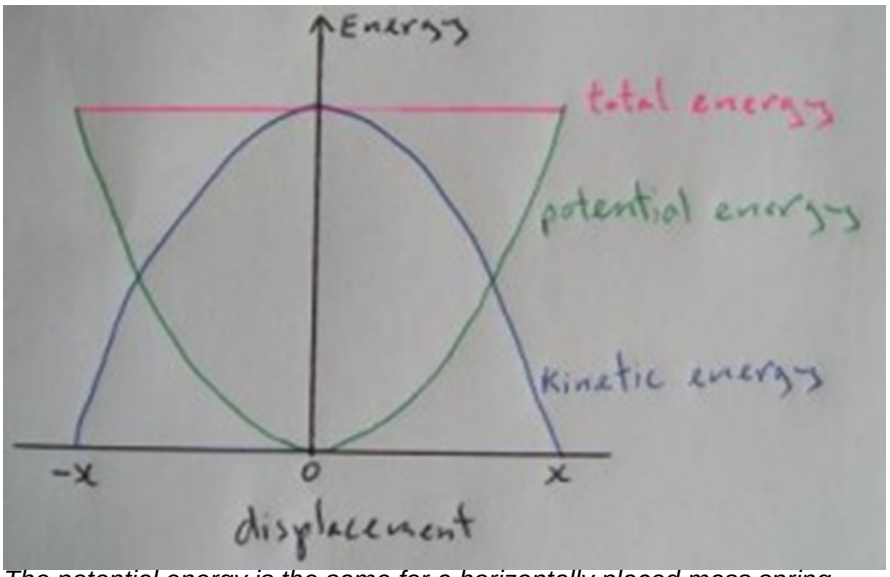
-The capacitance is reduced by the equation $C = \varepsilon A/d$.
-If the battery is connected ⇒ constant voltage ∴ energy decreases ■ $E = ½ CV^2$.
-If the battery is disconnected ⇒ constant charge (cannot leave) ∴ energy increases ■ $E = ½ Q^2/C$ ■ work is done to move them apart.

186. What is SHM and what is required of an object to undergo it?

-A type of oscillation.
-Its acceleration must be ∝ to its displacement from equilibrium position.
-Its acceleration must be directed towards equilibrium position.
So...
$a = -\omega^2 x$ from $a \propto -x$
Thus, the same is expected of the restoring forces.

187. Draw a graph of the energies under SHM

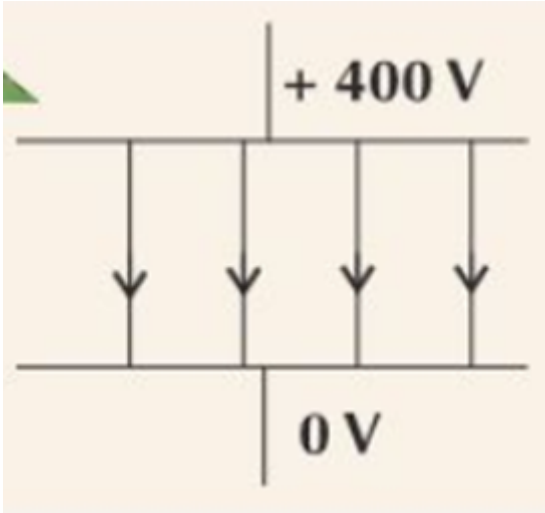
-The total energy is supplied by the initial displacement.



The potential energy is the same for a horizontally placed mass spring system.

188. How is a uniform electric field produced?

By connecting two parallel plates to opposite poles of a battery.



189. What is elastic strain energy?

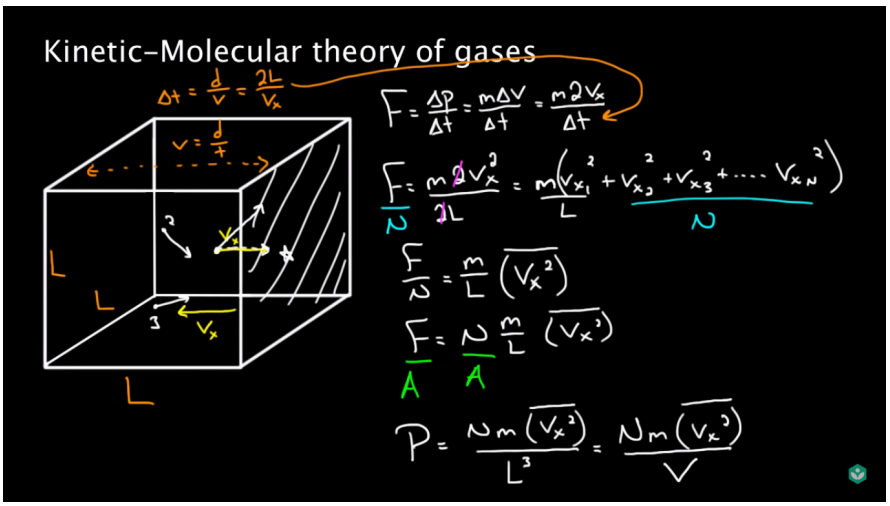
The stored potential energy in an elastic object - all the work done in stretching it.

190. When does Boyle's Law cease to work and why?

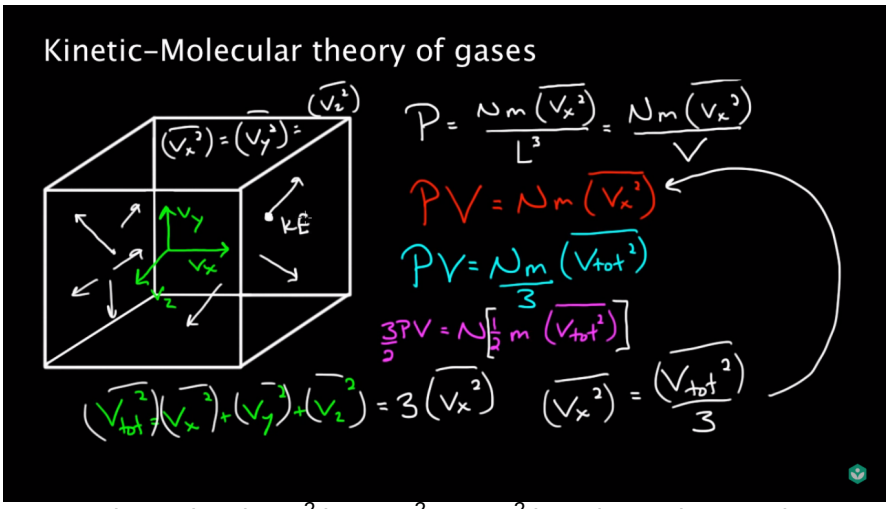
- At very high pressures as molecules are so close together that their net volume becomes a larger fraction of volume of container.
- Intermolecular forces can no longer be ignored.

191. Derive the relationship between K_E and temperature

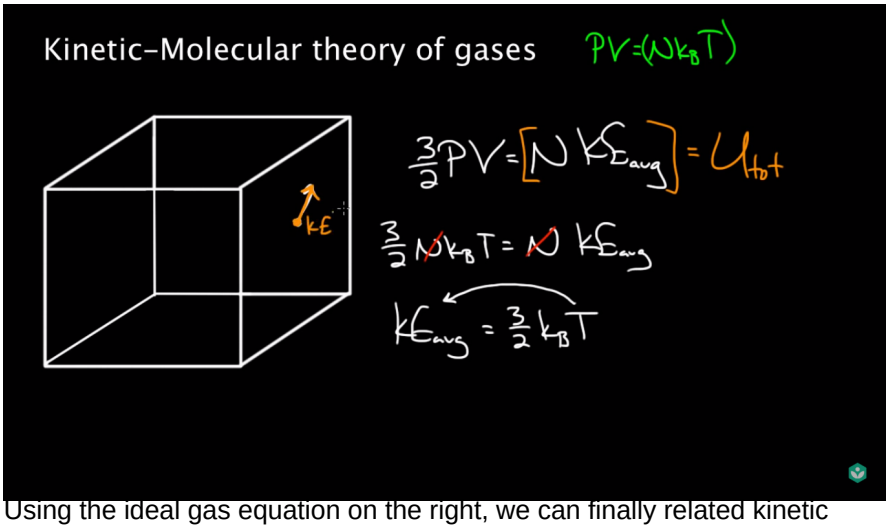
$$\frac{1}{2}m(c_{rms})^2 = \frac{3}{2}kT = \frac{3RT}{2N_A}$$



Consider a box of side length L. We can calculate the force by considering the change in momentum when it hits the wall and the time between collisions (since this is the change in momentum / s). Then we add all the velocities and divide by the number of molecules. Convert this into pressure.



Now, we know that the v_x^2 is ■ v_{tot}^2 or c_{rms}^2 by using Pythagoras in 3D. We can get kinetic energy on the right.



Using the ideal gas equation on the right, we can finally related kinetic energy to temperature.

192. What is magnetic flux density defined as?

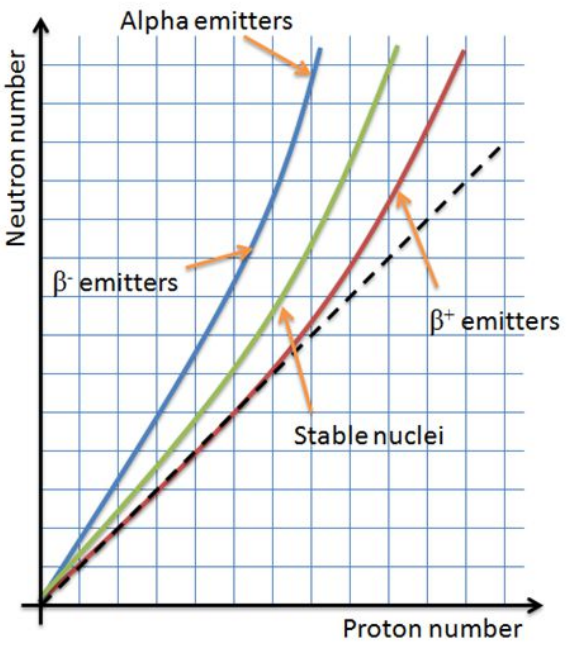
$$F = BIl$$ will be useful.

Force per unit length per unit current on a current carrying conductor at **right angles to the magnetic field**. Measured in Tesla (T).

$$B = \frac{F}{Il}$$

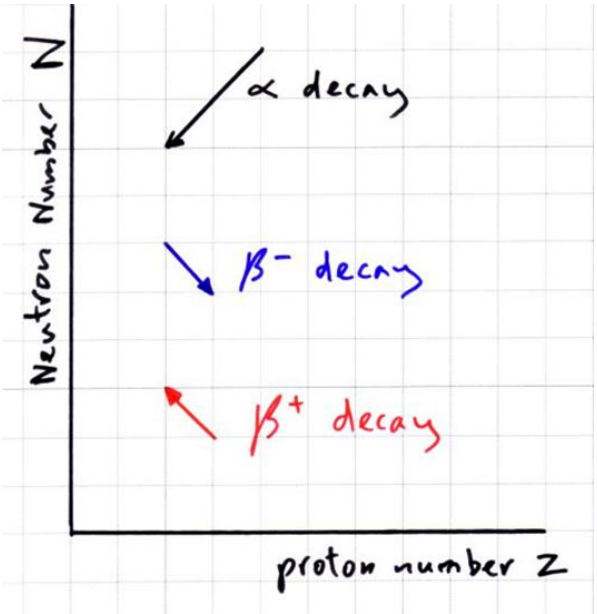
If you're asked to define THE TESLA, then you need to mention 1 N.

193. Draw the graph showing the line of stability and explain it



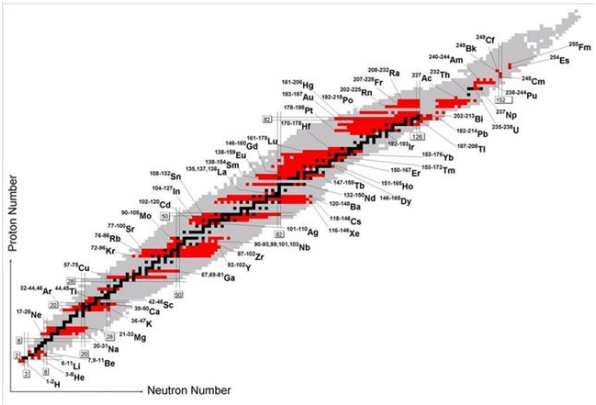
Alpha emitters are near the top at around Z > 60 and N > 80.

- Blue line - neutron rich so decays with a neutron turning into a proton.
- Red line - proton rich so decays with a proton turning into a neutron.
- The decay arrow acting towards the line of stability are as shown:



You can see that for light isotopes where z = 20, the stable nuclei have an equal number of protons and neutrons. For heavier nuclei, they need more neutrons than protons to spread protons out thus reducing the electrostatic repulsion between them.

This relates quite nicely to this…



194.	How does radioactive dating work?	Once a plant or animal dies, its carbon-14 content gradually decreasing and by comparing the amount found on the ancient artifact with the amount we would expect, we can date it. *We often assume the proportion of carbon-14 in the atmosphere has stayed constant which depends on whether the amount of cosmic rays penetrating the atmosphere was the same.*
195.	How are different levels of radioactive waste handled? What risks need to be addressed? Give examples of each	**LOW-LEVEL:** - Protective clothing and obsolete equipment. - Buried **DEEP** underground. **INTERMEDIATE-LEVEL:** - Parts of reactor. - Put in steel drums, are encased in concrete, and buried **DEEP** underground. **HIGH-LEVEL:** - Spent fuel rods / reactor parts. - Placed in cooling ponds for years. - Vitiried in glas, encased in metres of concrete, and stored **DEEP** underground. **RISKS:** 1. Hot so needs to be placed in cooling ponds (to remove heat). 2. Needs to be vitrified because hazardous in liquid form. 3. Needs to stored for thousdands of years so needs to be in geologically stable sites (no earthquakes). *Fuel rods aren't completely used, it has to be a critical mass so spent fuel rods are a waste product.*
196.	Why is fusion difficult to achieve?	As nuclei have to be close enough for the SNF to get involved (1) yet the electromagnetic force is repulsive (1) so only nuclei with high energy can do this.
197.	Why do heavier nuclei need more neutrons than protons?	To spread out electrostatically-repelling protons thus reducing the repulsion between them.
198.	What is an intrinsic semiconductor?	A pure semiconducting material.
199.	What is the effective resistance for parallel resistors and why?	- The reciprocal of the total resistance is equal to the sum of the reciprocals of the resistances of all the components. - As it increases the possible routes for current to take thus making it easier for current to flow and thus the effective resistance smaller. *This is because you that know* $I_T = I_1 + I_2 \Rightarrow V / R_T = V / R_1 + V / R_2 \Rightarrow 1 / R_T = 1 / R_1 + 1 / R_2$

200. How does current work in parallel and why?

It **splits up** at a junction a**ccording to resistance**; **more current** will flow via the **least resistance** because voltage has to be constant.
Think of charge as being lazy, more will flow down the route with the least resistance.

---

201. How do particles and their antiparticles differ?

In all their properties (i.e., charge, lepton number, baryon number, and strangeness) **EXCEPT** for rest mass.

---

202. What are muons and what can they decay into?

Heavy electrons which decay into electrons, some electron neutrinos, and some muon neutrinos as shown below:

$$\mu^- \rightarrow e^- + \bar{\nu}_e + \nu_\mu$$

$$\mu^+ \rightarrow e^+ + \nu_e + \bar{\nu}_\mu$$

As shown, if you have a muon then you will have a muon neutrino too. Likewise with an electron.

---

203. What is stopping potential?

Minimum p.d. required on a metal plate to attract all photoelectrons emitted from the surface back.

---

204. What is the excitation/de-excitation amount determined by?

$$hf = E_1 - E_2$$

---

205. What wave-like and particle-like properties do electrons exhibit?

- Wave-like - electrons diffract and interfere when passing through a small enough gap.
- Particle-like - electrons are deflected in electric and magnetic fields.

---

206. What will you always have at a closed and an open end of a standing wave?

-A **node** at a **closed** end.
-An **antinode** at an **open** end.

---

207. What is quark confinement?

Applying enough energy to quarks to "separate" them yet producing a quark-antiquark pair instead.

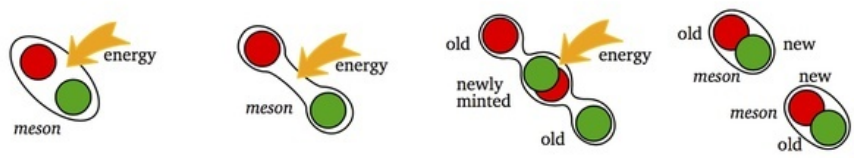


Figure –1.5: Inseparability of quarks and antiquarks in spite of investing ever more energy

---

208. What is each variable in the formula for diffraction gratings?

$$\sin\theta = \frac{n\lambda}{d}$$

d being the distance between two slits, θ being the angle of diffraction (i.e., the angle from the normal of the screen), n being the order number.

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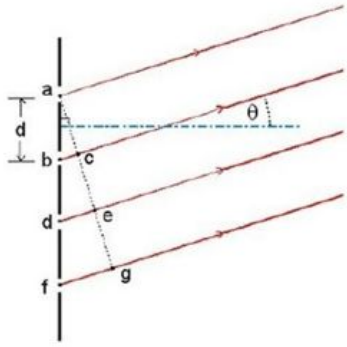
209. How can the formula for diffraction gratings be derived?

nλ = d sinθ
(Required)



Consider a diffraction grating with slit spacing *d*.

For the beam leaving *a* and *b* to form the first maxima on the screen they must be in phase ∴ path difference of λ.

Distance *bc* must therefore be λ (or nλ as 1st order).

Distance *ab* must = *d*

Angle bâc = θ

Using trig.

Sinθ = opp/hyp (opp = nλ, hyp = d)

∴Sinθ = nλ/d

(or nλ = d sinθ)

If you consider Δ***ade*** *with* ***ad*** *as 2d and* ***de*** *as 2λ, you'll get sinθ = λ/d where n = 1. However, for the second order,* ***bc*** *is 2λ so* ***de*** *is 4λ will give you sinθ = 2λ/d where n = 2*

---

210. What are the roles of exchange particles?

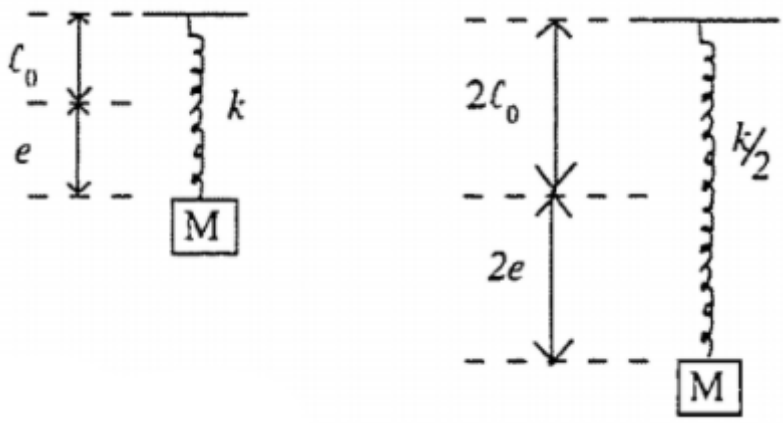
- Transfer force.
- Transfer energy.
- Transfer charge (sometimes).

---

211. What is the equation for Hooke's law in series and why?

$$\frac{1}{k_T} = \frac{1}{k_1} + \frac{1}{k_2}$$

There is a force of Mg pulling on **BOTH** springs ⇒ overall extension is double (as there are two springs) ⇒ the overall spring constant has to be k/2.



On the load-extension graph, you have a greater extension on the equivalent spring for less force so the line is shallower. You can think of this as a longe bungee rope stretching more than a shorter one.

---

212. What does 'tensile' mean?

The material is under tension - it's being stretched.

---

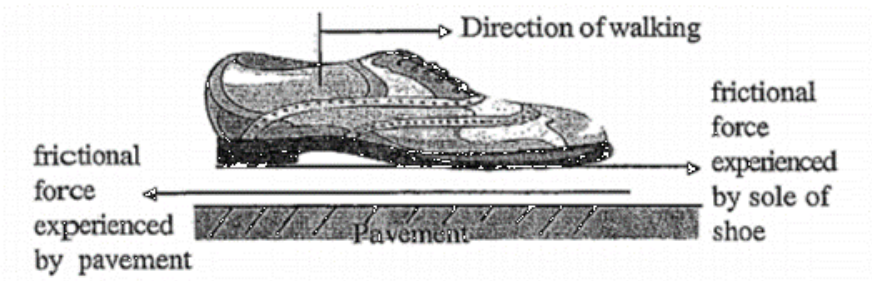
213. Why does '$K_{E\ (max)}$ depends on the frequency of EM wave' support the particle theory over the wave theory?

- Wave theory - energy ∝ intensity ∴ greater intensity ⇒ higher K_E electrons.
- Particle theory - the $K_{E\ (max)}$ depends on frequency and work function as defined by $K_{E\ (max)} = hf - \varphi$.

---

214. Give an example of Newton's Third Law and explain the importance of frictional forces

- By walking, you push the earth backwards yet the earth pushes you forward (somewhat like a car)
- This is a result of frictional forces. Without them, you couldn't walk (like on ice) or even hold a ladder against a wall.



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215. What happens when a ball hits a wall with reference to Newton's Laws?

- It will experience a change in momentum thus exerting a force on the wall.
- The wall will exert an equal and opposite force on the ball.

216. Define ‘centrifugal force’ with 2 examples

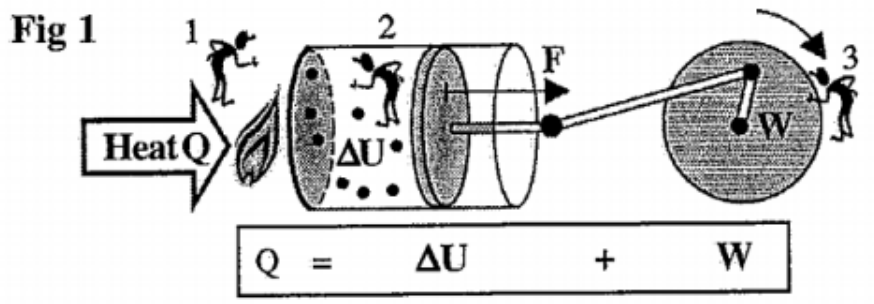
-An apparent ‘force’ due to the inertia of a body.
-Holding on to the railings on a merry-go-round, you’ll feel pushing outwards (centre-feeling force).
-Water droplets flying off when a propeller spins too fast.
-In both cases, its the inertia of the body trying to continue in a straight line. For the former, it is pulled back inwards. For the latter, the friction isn’t great enough (so it cannot provide a sufficiently great centripetal force).

217. What is the 1st Law of Thermodynamics?

The internal energy of a system equals the heat added to it minus the work done by the system:

$$\Delta U = \Delta Q - \Delta W$$

So an isothermal change (constant temperature) will mean no change in internal energy so heat applied = work done by gas. Whereas an adiabtic change (no heat loss/gain) mean internal energy = minus work done by gas and internal energy is decreasing.
Example:



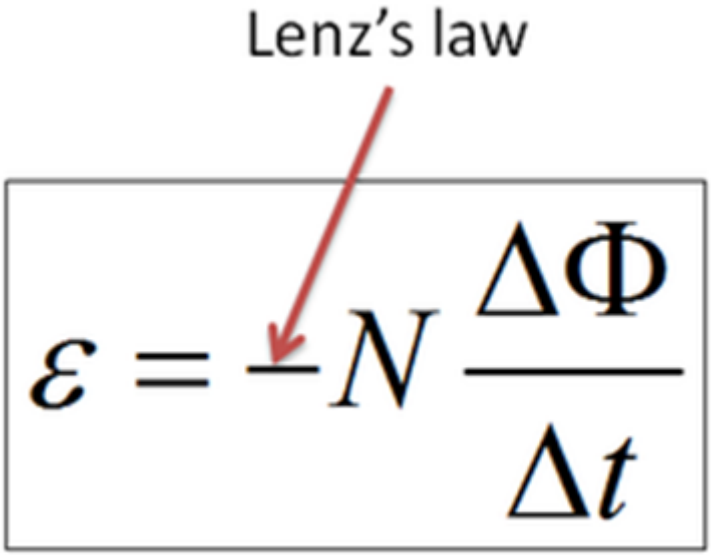
If 100 J of heat enters the gas and 70 J is given to gas molecules then 30 J must appear as work done.

218. What is Avogadro’s Law? (with example)

- Volume Gas ∝ Number Moles of Gas at constant pressure and temperature. Independent of gas itself.
- Eg, if there are 2 moles of O_2 in 50cm^3 of oxygen gas, then there will be 2 moles of N_2 in 50cm^3 of nitrogen gas and 2 moles of CO_2 in 50 cm^3 of carbon dioxide gas at the same temperature and pressure.

219. What is Lenz's Law?

Direction of induced emf (when there is a change of flux linkage) is such that it will (try) to **OPPOSE the change** (of
flux) that is producing it .
In more detail, the direction of a current induced by a changing magnetic field is such that the magnetic field by the induced current opposes the initial changing magnetic field.



The explanation of this comes from the conservation of energy. Induced current can never be in a direction to help the change that caused it otherwise your producing electrical energy from nowhere.

---

220. Describe the Rutherford Gold Foil experiment (with explanation)

- Fire a stream of positively charged α particles to a **thin film** of gold IN an **evacuated chamber**.
- **Evacuated chamber** to prevent scattering / absorption of alpha particles by air molecules.
- **Thin film** so alpha particles aren't absorbed.

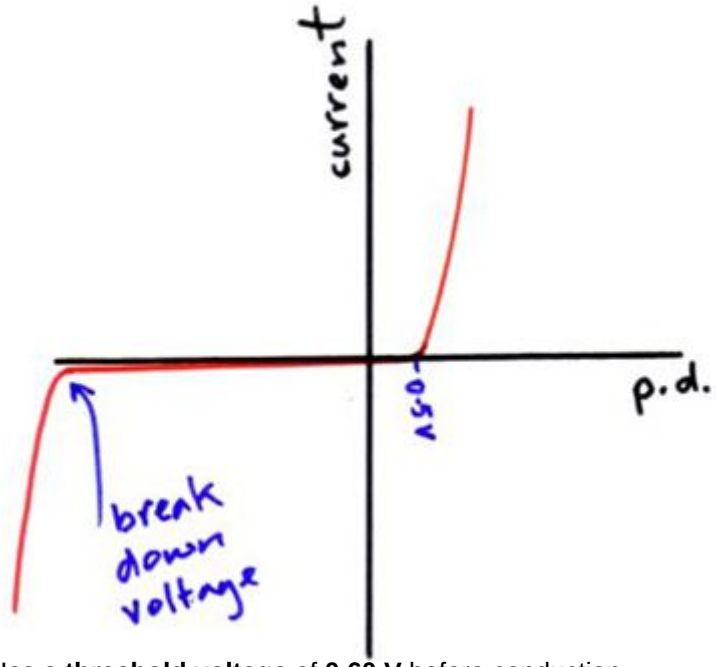
---

221. How can radioactive tracers be used in construction?

To detect for leaks in a pipe since the count-rate will increase where the leak occurs since the pipe will block both alpha and beta emissions.
Here gamma rays would not be suitable since the pipe wouldn't block this.

---

222. Give the current-voltage graph of a diode with an explanation



- Has a **threshold voltage** of **0.60 V** before conduction.
- Can **conduct** in the **reverse direction** if the p.d. is high enough (this is its **breakdown voltage**).

---

223. Why were neutrinos hypothesised?

To account for conservation of energy and momentum in beta decay.

---

224. Why is measuring emf using an open/close switch and a voltmeter not ideal in reality?

There's still some current flowing through the circuit to power the voltmeter so by $\varepsilon = V + Ir$, $\varepsilon \neq V$. This current leads to the internal resistance having an effect.
Thus, it's better to measure emf indirectly. Yet, in an ideal physics world, where a voltmeter has infinite resistance, no current passes via the circuit so the internal resistance has no effect so the emf is displayed.

---

225. What are mechanical waves (with examples)?

Waves that rely on a medium to travel through (e.g., sound waves and seismic waves).

---

226. What is refraction?

- When a wave changes direction as it moves from one medium into another.
- **T**owards **A**ir **G**lass **A**way **G**lass **A**ir

---

227. Give two conditions needed for total internal reflection to occur

- Light travelling from a **more dense to a less dense medium**.
- The **angle of incidence** ≥ **critical angle**.

---

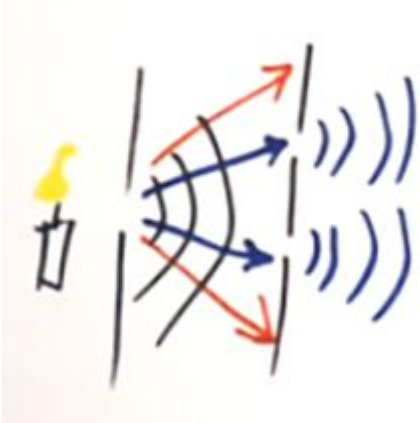
228. How can material dispersion be resolved?

By using monochromatic light.

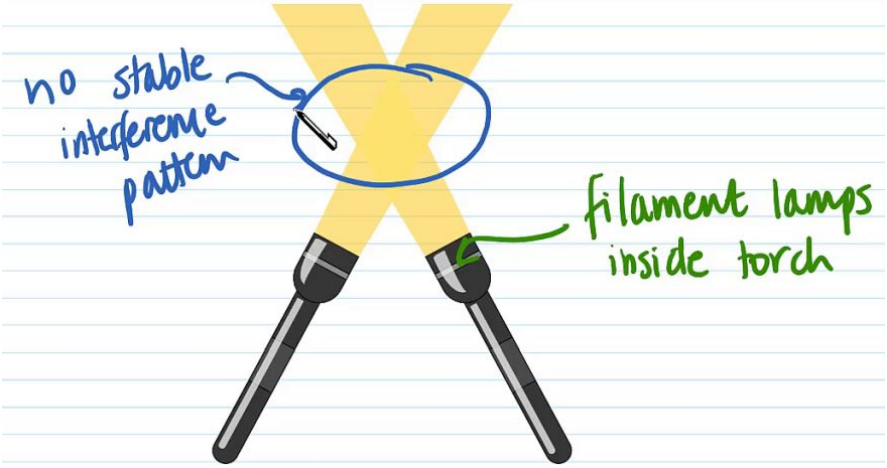
---

229. Give 2 reasons Young used a single slit in his double-slit experiment

- To diffract light to both slits.
- To create **monochromatic**, **coherent** light.



Blue light diffracts the least and thus comes out the other two slits. Without coherent waves, there is no stable interference pattern as shown below:



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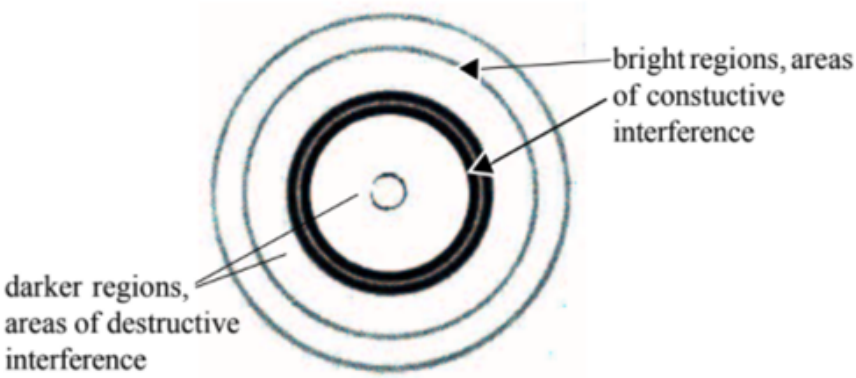
230. How can the wave-like nature of electrons be observed?

1. Fire electrons via a crystalline structure causing them to diffract onto a fluorescent screen.
2. An illuminated pattern of concentric bright and dark circles is formed corresponding to areas of constructive and destructive interference respectively.



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231. What is stopping distance and the factors affecting it?

Sum of thinking and braking distances.

Factors affecting stopping distances	
Thinking distance	**Braking distance**
• Fatigue • Intoxication/drugs • Age • Distractions • Speed (∵ s = ut)	• Brakes • Tyres • Road conditions • Speed

232. Which two particles are their own antiparticles?

π^0 and k^0.

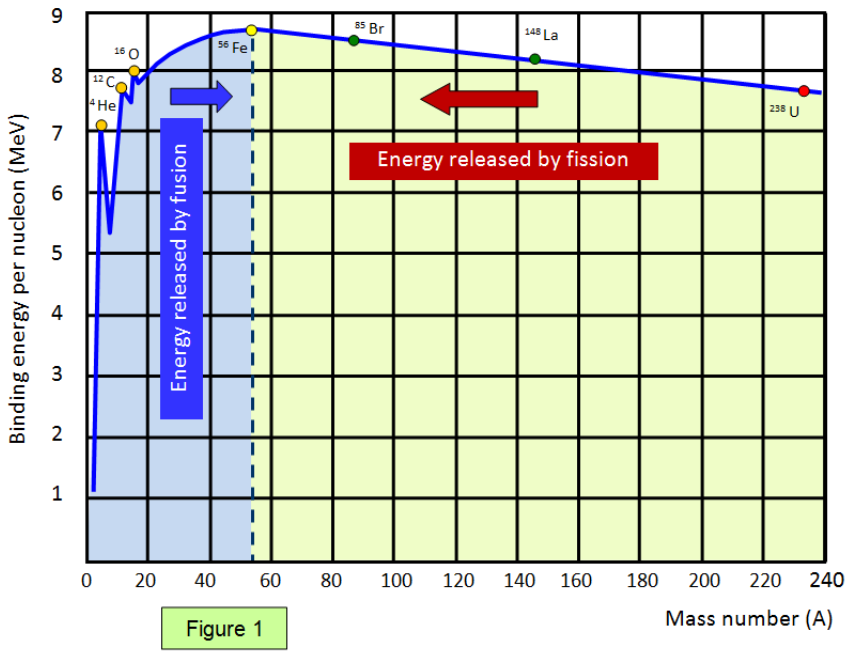
233. What 2 assumptions are made in the Gravitational Field Strength equations?

-The mass is very small (called a test mass), otherwise, it'll affect the position of the larger object and thus the position of itself in the field.
-That you're above the surface off the planet as the mass of the planet in the equation has to be below you.
The latter point explains why g decreases as you dig inside a planet.

234. Define isothermic

Constant temperature.

235. Draw and describe the graph for ‘Binding Energy per Nucleon’ v ‘Nucleon Number’ (with features)

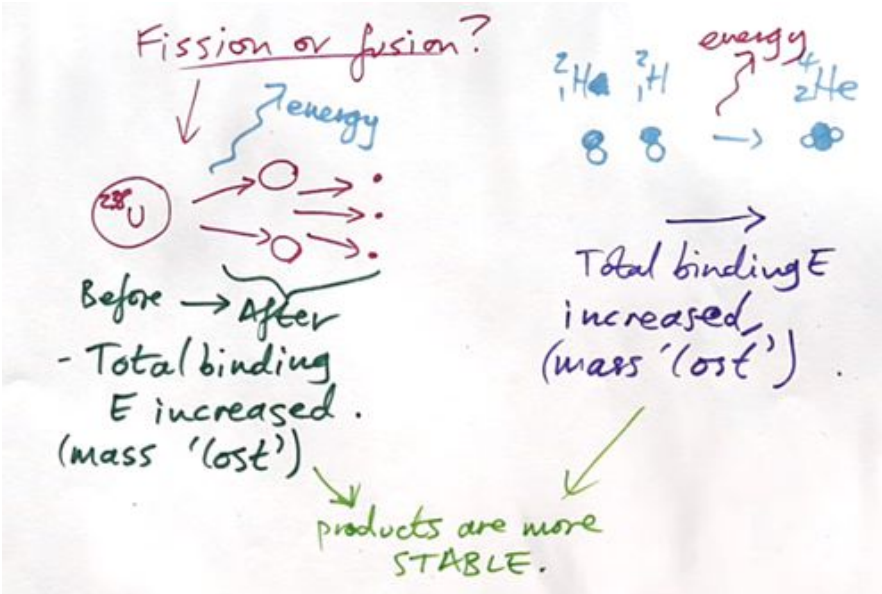


Key features of the graph are as follows:

1. The peak is at 8.7 MeV between 50 - 60 (since Fe-56).
2. Rises sharply and falls to no less than 2/3 of peak height.
3. Unusually high peak at He-4 (hence why alpha particles are emitted.)

●Fusion occurs to the left of the peak. Fission occurs to the right.

As shown below, in both cases, energy is given out and products become more stable. It is less stable as you go further right as the strong nuclear force cannot hold all the neutrons together.



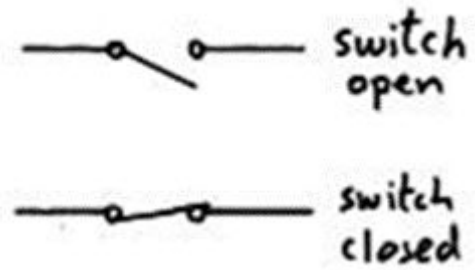
It gets more stable towards iron as a lot more energy is required to remove each nucleon from its nuclide. For this reason, its difficult to fuse heavy nuclei or fission light nuclei as more energy is required than you get out.

236. How are nuclear reactors designed to minimise risk of exposure to radiation? How does one of these precautions become radioactive?

1.Shielding:
■Steel casting and several metres of concrete surround the reactor core.
■Shielding absorbs nuetrons (1) converting them into unstable isotopes (1).
Remember that things have to absorb neutrons to become radioactive.
2.Emergency shutdown:
■Control rods are dropped into the reactor if the rate of fission increases.

---

237. What is the circuit symbol of a switch?



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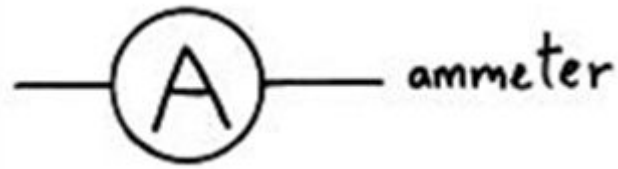
238. What is the circuit symbol of an ammeter?



These ideally should have zero resistance.

---

239. Give an example of a strange particle

A kaon.

---

240. What 3 things are unusual about strange particles?

1. Produced by strong interaction (∴ strangeness **IS** conserved) **YET** decay by weak interaction (∴ strangeness **IS NOT** conserved).
2. They are always produced in particle-antiparticle pairs (∴ strangeness of 0 is conserved in strong interaction).
3. They have relatively long half-lives.

---

241. What is amplitude?

MAXIMUM displacement from rest position.

---

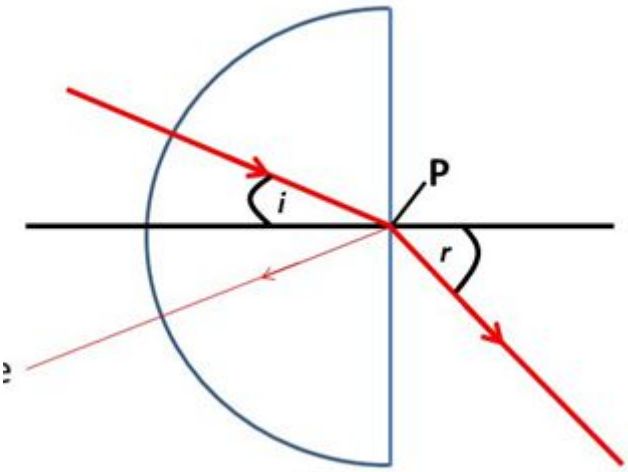
242. What remains constant under refraction?

Frequency.

---

243. Why is a semi-curricular block often used for total internal reflection?

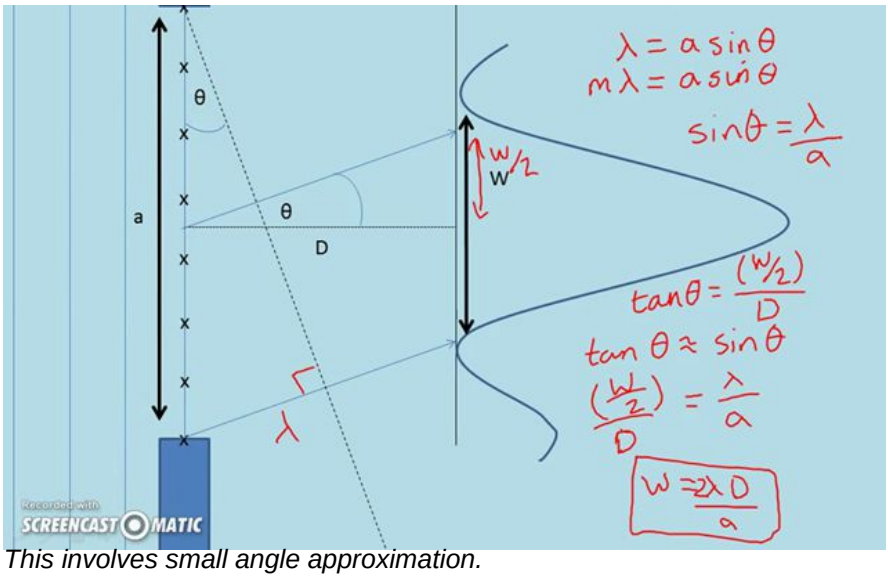
As you want the curved side to have an angle of incidence of 0°.



244. What is material dispersion and its effects?

Different wavelengths of light travelling at **different speeds** via an optical fibre leading to **pulse broadening**.

245. How can you derive the equation for the width of the central fringe for single slit diffraction?

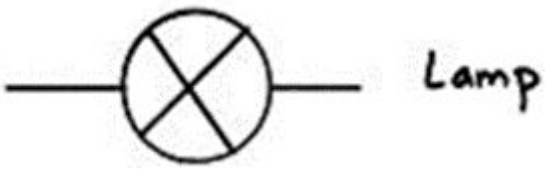


This involves small angle approximation.

246. What is tensile strain (ε)?

The extension of a material divided by its **original length**.

247. What is the circuit symbol of a lamp?



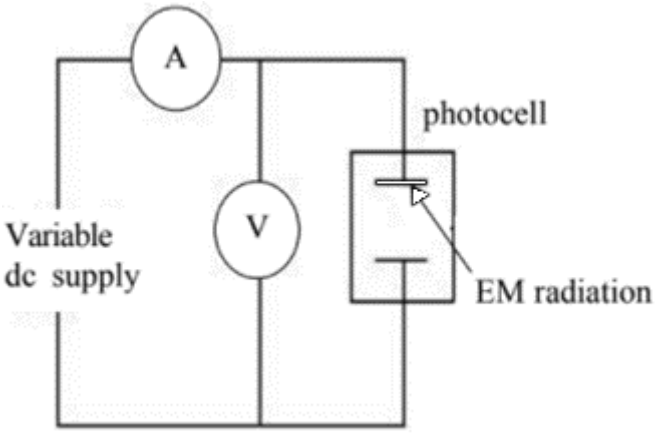
248. What is 1 C?

The **amount of charge** that flows via a point in **1 s** when there is a current of **1 A**.

249. Why are superconductors used (with examples)?

To have **NO ENERGY LOSSES** in machines with huge currents (e.g., in particle accelerators).

250. Describe the set up of the vacuum photocell with a precaution



- The metal surface is the anode (∴ positively charged so can attract e^-'s back).
- Light with frequency > f_0 is shone on the anode so that photoelectrons are emitted.
- Applying a sufficient p.d will cause electrons to be attracted back ∴ current flows.
- The photocell is evacuated to prevent photoelectrons colliding with air molecules.

---

251. What happens when two waves meet? What does this mean?

They **superpose** (1) meaning the **resultant displacement** is now the **vector sum** of the **individual displacements**.

---

252. How is energy transferred when accelerating and at terminal velocity during a skydive?

- Accelerating - GPE = KE + Q.
- Terminal velocity - GPE = Q (as work is being done again particles). Where Q is heat energy.

---

253. What's the difference between heat and temperature?

- Heat (Q) is a type of energy measured in J.
- Temperature is how fast particles are vibrating.

---

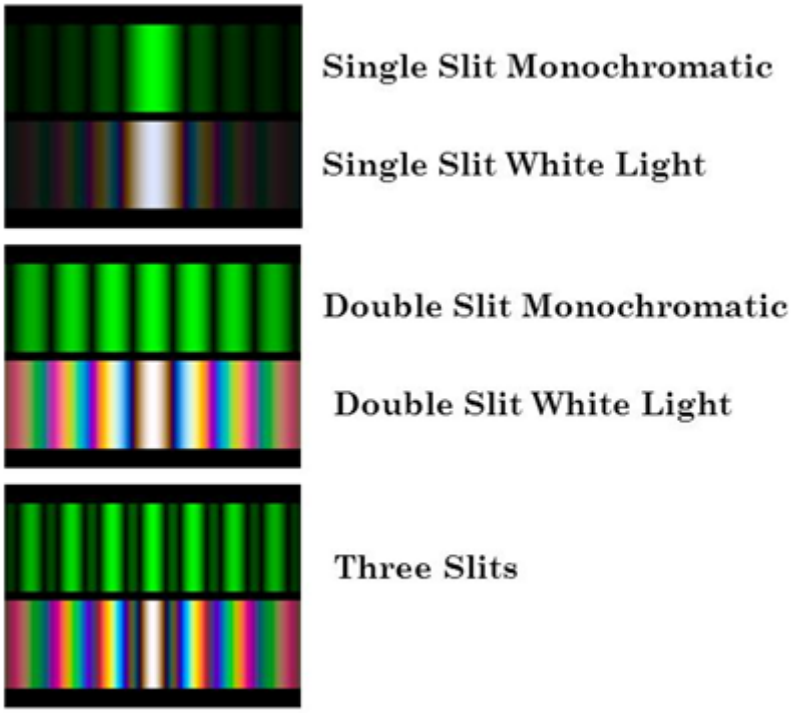
254. When is work done on or by a gas?

- Work is done on a gas when it is being compressed.
- Work is done by a gas when it is expanding.

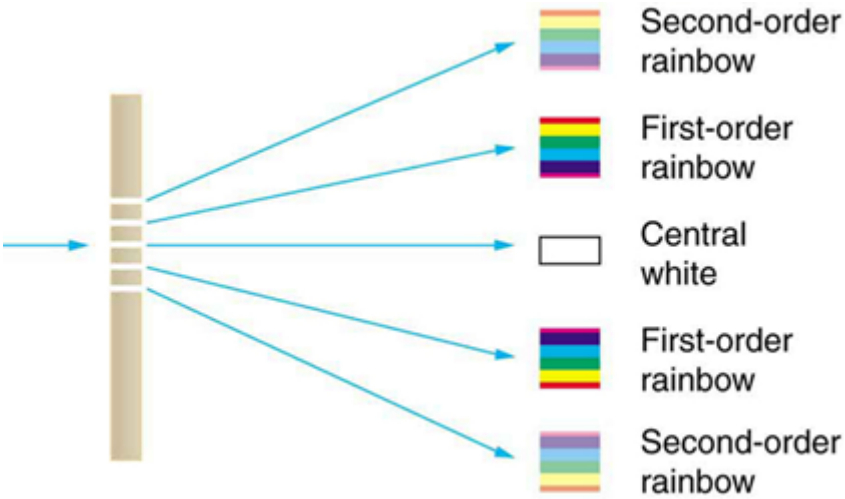
---

255. What appears on a screen when using white light with a single slit, double slit, and diffraction grating?

A central white fringe with a rainbow repeated at every other order of lower intensities when further from the centre.



All the fringes are the same width except the central fringe for the single slit experiment.



White light isn't diffracted in the centre as the angle of diffraction is 0°.

256. What is the decay constant λ defined as?

The probability that a nucleus will decay in the next second (s^{-1}).

$$\frac{\Delta N}{\Delta t} = -\lambda N$$

So…

$$A = \lambda N$$

This makes sense if you think about it since multiplying the probability of decay per second by the number of nuclei will give you the number of decays per second.
And using differential equations of dN/dt = -λN, you can derive:

$$N = N_0 e^{-\lambda t}$$

---

257. What is binding energy?

The energy required to split the nucleus into its individual separate nucleons
This is related to mass defect by the following:

$$\text{Binding Energy} = \text{Mass Defect} \cdot c^2$$

This is equal to the lost potential energy when the nucleons came together into a nucleus.

---

258. What is equal in a potential divider circuit and why?

The ratio of the voltages to the ratio of the resistances because current is constant.

$$\frac{V_{out}}{V_{in}} = \frac{R_{out}}{R_T}$$

---

259. What happens during alpha decay? Why?

$$^{A}_{Z}X \longrightarrow {}^{(A-4)}_{(Z-2)}Y + {}^{4}_{2}\alpha$$

A radioactive parent nuclide decays into a lighter daughter nuclide by emitting an alpha particle as the strong nuclear force can no longer hold the nuclide together.
This is because nucleons on opposite sides of the nucleus repel each other.

---

260. What is the electromagnetic force and its force carrier?

When charged particles repel or attract each other by exchanging virtual photons.

---

261. What type of waves cannot be polarised and why?

- Longitudinal waves.
- As their oscillations always occur in one direction - in the direction of the way - so there's no need to distinguish between 'different' oscillation directions as there's only one.

---

262. What will always be in the centre of a diffraction pattern and why?

- The **maximum bright fringe**.
- As the **centre** is **symmetric** to all the slits so light from each slit will travel a whole number of waves to reach it, **arrive in phase** and **constructively interfere**.

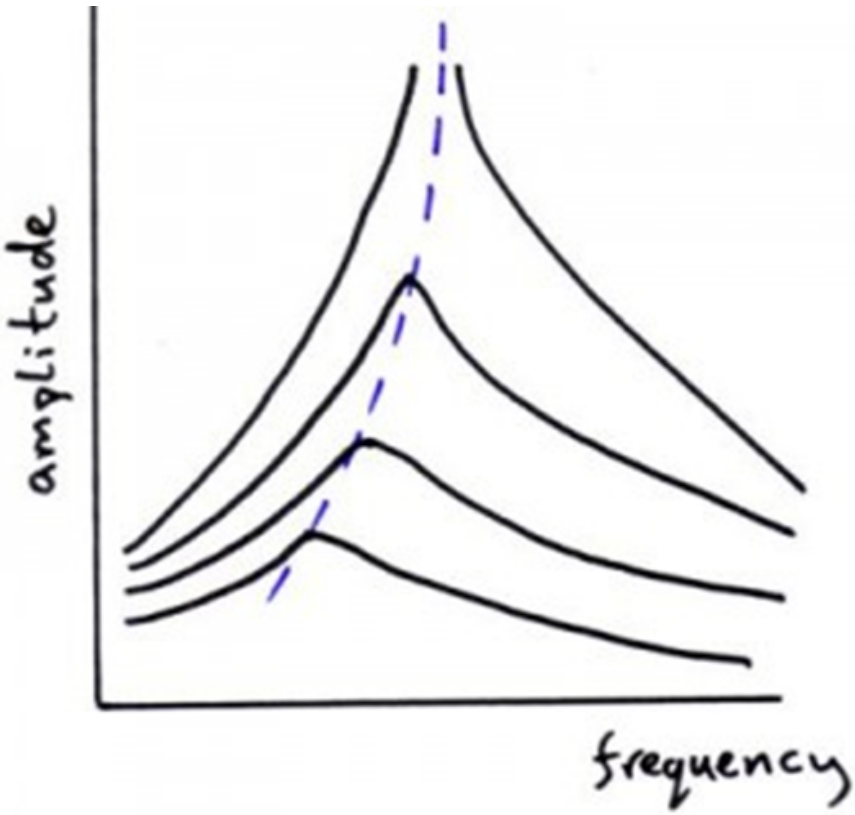
---

263. What is plastic and elastic behaviour?

-Plastic behaviour - doesn’t return to its original shape after forces removed.
-Elastic behaviour - returns to its original shape after forces removed.

---

264. What is the effect of damping on resonance?



The heaver the damping, the further the resonant frequency is to the natural frequency of the object and the smaller the amplitude.

---

265. What is the activity of a sample defined as?

The average number of disintegrations per second measured in **becquerels (Bq)**.

$$activity = \frac{\Delta N}{\Delta t}$$

ΔN = change in number of undecayed nuclei
Δt = change in time in seconds

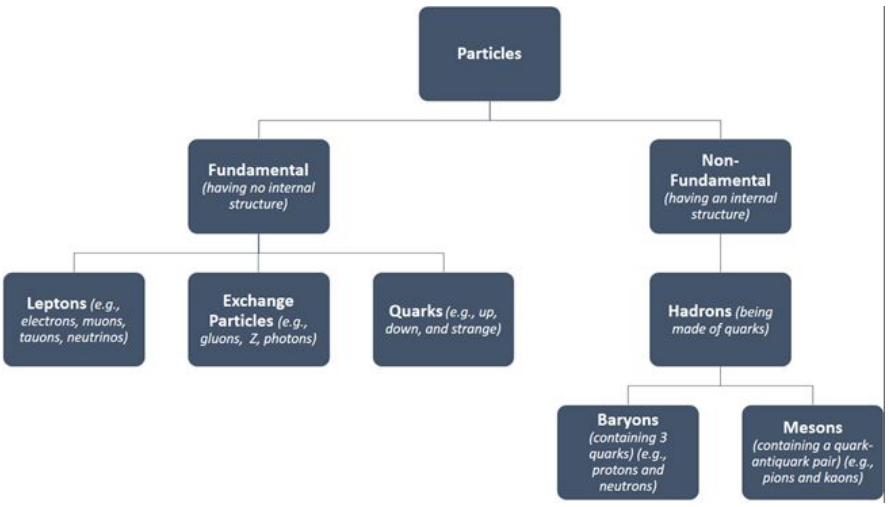
---

266. How do you find specific charge?

Divide the charge (C) of the object by its mass (kg).

---

267. Sketch the family tree of particles



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268. Give 3 properties of electromagnetic waves

-Can travel through a vacuum.
-Travel at the speed of light (through a vacuum).
-Are all transverse.

---

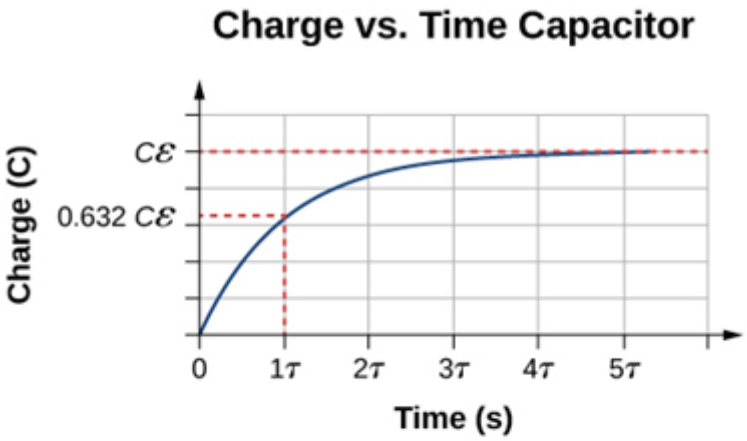
269. What is necessary when turning and how do banked tracks help?

-The centripetal force (provided by friction) to be sufficiently great. The frictional force on an icy surface is low ∴ you have to turn at a low speed.
-Banked tracks provide both friction and a reaction force ∴ turns can be made at higher speeds.

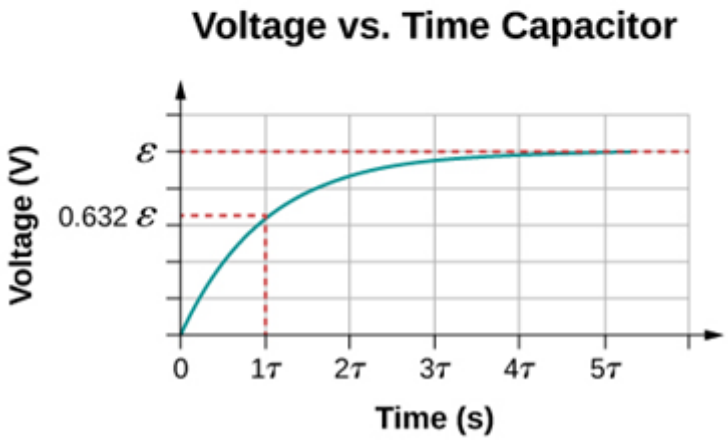
---

270. What is the charging graph of a capacitor from the question?

$$Q = Q_0(1 - e^{-\frac{t}{RC}})$$



(a)



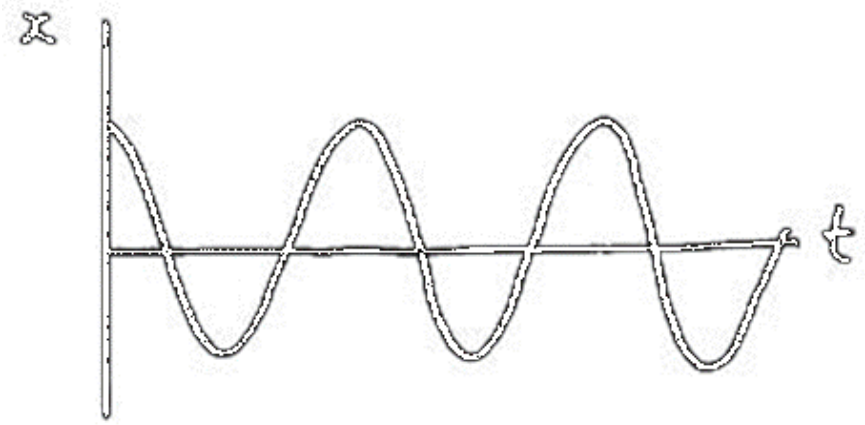
(c)

The same can be written replacing Q and Q_0 with V and V_0 respectively.
It tapers off to the emf of the battery because the rate at which charge comes in decreases. (The shape is the same as V = QC where C is a constant).
It's considered fully charged after 5 time constants.

---

271. What are free oscillators?

Oscillators with **NO** periodic driving force acting on it:



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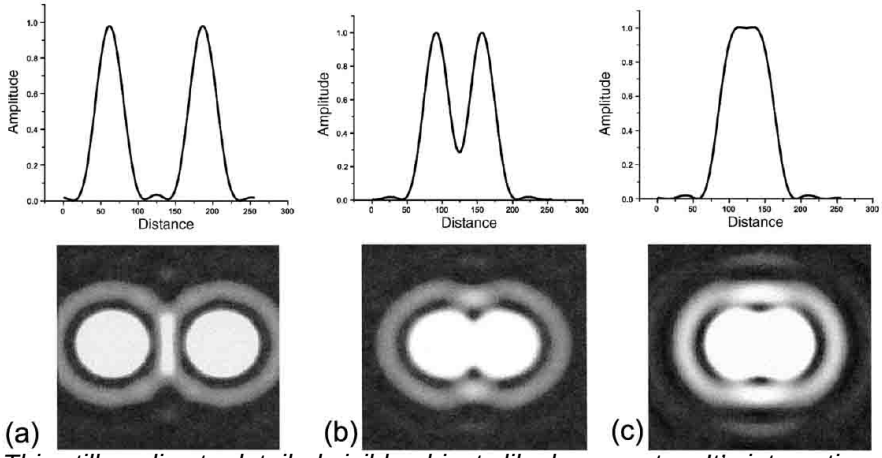
272. What is the Rayleigh criterion?

Two objects will just be resolved when first minimum of air disc in diffraction pattern of one image (1) coincides with central maxima of airy disc of other (1).



This still applies to detailed visible objects like lunar crates. It's interesting to note that around half the stars in the night sky we see are collections of two or more stars yet our eyes see them as a single star since the angle is too small to resolve.

---

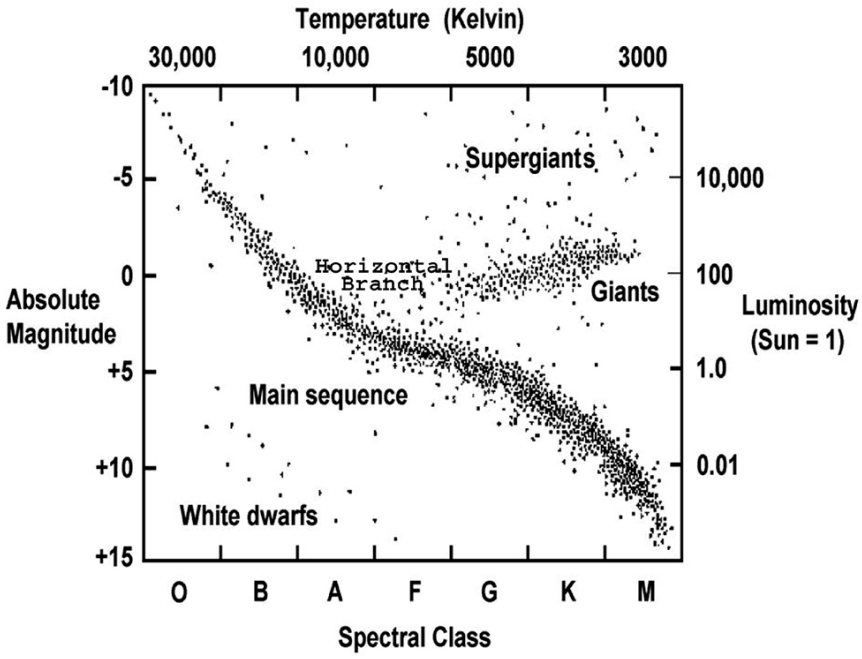
273. What are the spectral classes, colors, temperature, and prominent absorption lines?

Spectral Class	Colour	Temperature / Thousands of K	Prominent Absorption Lines	
O	Blue	25 - 50	He	H
B		11 - 25		
A	Blue-White	7.5 - 11	Ionised Metals	
F	White	6 - 7.5		
G	Yellow-White	5 - 6		Neutral Metals
K	Orange	3.5 - 5		
M	Red	2.5 - 3.5	TiO	

This can be remembered as 'Oh Boy, An F Grade, Kill Me'.

---

274. Draw the Hertzsprung-Russell diagram with the sun's position



The bottom ranges from 50k to 2.5k.
The Sun has spectral class of G and absolute magnitude of 4.8.

---

275. Describe the formation of stars

1.Dust and gas clouds contracts under gravity becoming denser and denser forming a protostar (star in making).
2.During collapse, GPE becomes KE making it hotter.
3.Once sufficient mass is reached, the temp. becomes high enough for fusion to occur.
4.Energy released as fusion occurs further heats the protostar into a main sequence star.
If sufficient mass isn't reach, it will gradually cool.

---

276. Give 4 pieces of evidence for the Big Bang

1.Redshift of galaxies showing expansion.
2.Cosmic Microwave Background Radiaiton:
- EM radiation from all parts of the universe (1)
- Spectrum has peak in microwave region (corresponding temperature of 2.7 K) (1) following black-body radiation curve.
- Interpreted as left over radiation from Big Bang as photons stretched to longer wavelengths and lower energies (1)
3.Relative abundance of H:He.
- Fusion occured when Universe was young resulting in production of helium from hydrogen (1)
- Fusion stopped as Universe expanded and cooled (1)
- Resulting in H:He in ratio 3:1 as it cooled too rapidly for larger nuclei to be created (1)
4.Dark energy.

---

277. What 2 fluids are used for the coolant in nuclear fission? What 2 properties should it have?

●Water or carbon dioxide
1.Should have a high specific heat capacity.
2.Be stable at high temperatures.

278. How does a cloud chamber work?

●You have super-saturated water vapour molecules.
●When an ionising particle passes through, it triggers the formation of water droplets.

279. Why are Balmer absorption lines seen in B or A class star?

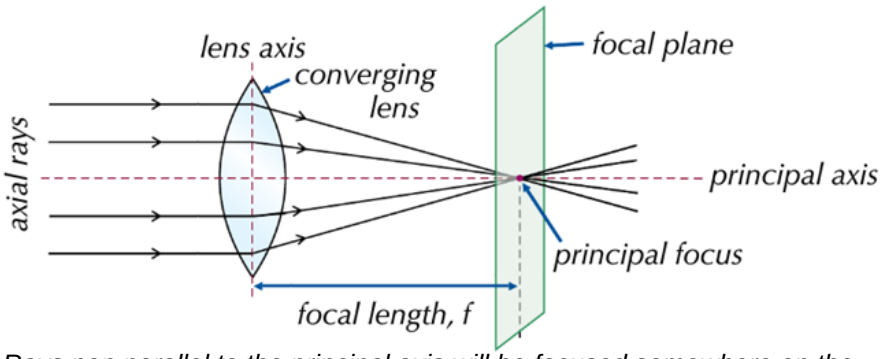
● Light from star passes via atmosphere of star (1)
● Which contains hydrogen with electrons in n = 2 star (1)
● Electron in this state absorb certain energies and hence frequencies of light.
● The light is re-emitted in all directions so the intensity of these frequencies is reduced in any given direction resulting in absorption lines (1)

280. What should the uncertainty be taken as when calculating the mean from a set of data?

Half the range of values given to the same number of d.p.
E.g., v_{mean} = 5.0 ms^{-1} and if the range were to be (5.3 - 4.6) / 2 = 0.35 then the uncertainty of the mean would be 0.4.

281. What is the focal plane of a lens?

The plane on each side of a lens perpendicular to the principal axis and containing the principal focus. See below:



Rays non parallel to the principal axis will be focused somewhere on the focal plane.

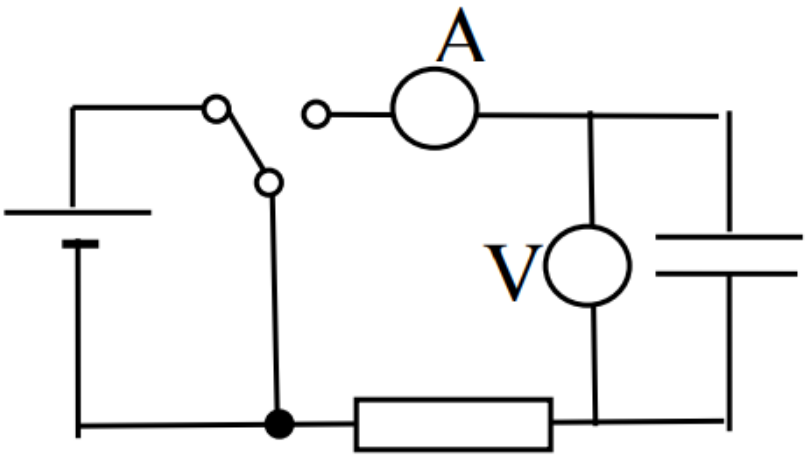
282. What is intensity and its relation to stars?

- I = P / A.
- Intensity of Star = Power / $4\pi r^2$ (thus following inverse square law).
- Where the power comes from Stefan's Law.
- Brightness of star ∝ intensity at Earth.

283. What is Wien's Displacement Law? What assumption is made in using this on a star?

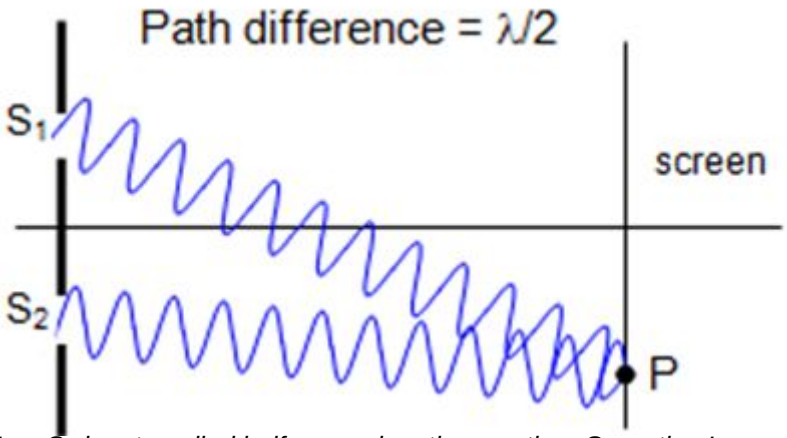
-The higher the surface temperature of an object, the shorter the **peak wavelength of black body radiation curve**.
-$\lambda_{max}T = 2.9 \times 10^{-3}$ mK
- The assumption in using this is that the star behaves as a black body.
mK is metres Kelvin.

284. Draw a circuit for a charging/discharging capacitor



285. What is path difference and what can it lead to?

- Path difference is the difference in distances travelled by two coherent waves.
- Path difference leads to phase difference.



E.g., S_1 has travelled half a wavelength more than S_2 so they're now completely-out-of-phase.

286. What affects multimode/multipath dispersion, why, and how can it be reduced?

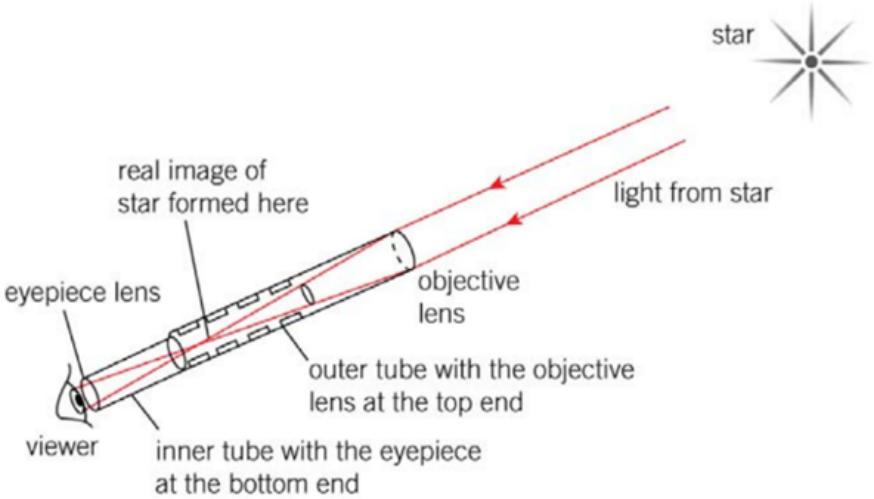
Cable length - the light has more time to disperse.
- Use relays for longer cables to reform the signal before significant pulse broadening has occured.
Cable thickness - the light is more likely to take a different path.
- Make the cable as thin as possible.

287. What is the internal energy of a system? (relating to individual molecules)

Sum of kinetic and potential energies (i.e., stored in bonds).
This thermal kinetic energy is the sum of the energies of all the particles moving in different directions. An object as a whole won't move. Whereas mechanical kinetic energy is where all the particles are moving in the same direction.

288. Describe a simple refracting telescope (and the image it forms)

-Has two converging lenses of different focal lengths.
-Lens with longer focal length is the **object**ive (since it's facing the **object**).
-Outer and inner tube (attached to objective and eyepiece lens respectively) move until image is in focus.

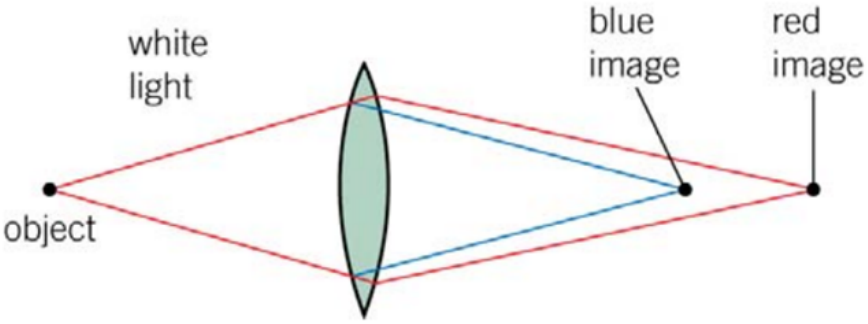


-Magnified, virtual, and inverted from eyepiece lens.
The objective lens focuses light from an object onto a point along the principal axis. We'd see the object if we placed a screen here.

---

289. What is chromatic aberration and when does it happen? What does it lead to?

- When shorter wavelengths are brought to focus nearer to the lens.



- It happens with refracting telescope.
- It leads to coloured edges.
Shorter wavelengths are refracted more as you can imagine them jiggling and interacting more because they have a higher energy, so they will bend more.

---

290. What is angular separation?

The separation of the straight lines from the Earth to each star.

---

291. Describe a CCD

An array of light-sensitive pixels that charge when exposed to light and discharge when connected to a circuit.

---

292. What are IR telescopes used to do and what precautions are taken on Earth?

-Detect IR emitted by dust clouds.
-On Earth, they have to be cooled to stop IR from their own surface **AND** have to be high and dry to prevent water vapour absorbing IR.

---

293. When does the parallax method only work?

-For stars that are close enough to see movement.
-On the ground, we can measure up to 100 pc because atmospheric refraction gets in the way.

---

294. Why are stars assumed to be black bodies?

1.As any incident radiation would be absorbed (none reflected).
2.The thermal radiation from a star closely matches the black body radiation curve.

---

295. What are the 2 forms of the Ideal Gas Equation and how are they relate?

$$PV = nRT = Nk_BT$$

since...

$$n = \frac{N}{N_A} \quad k_B = \frac{R}{N_A}$$

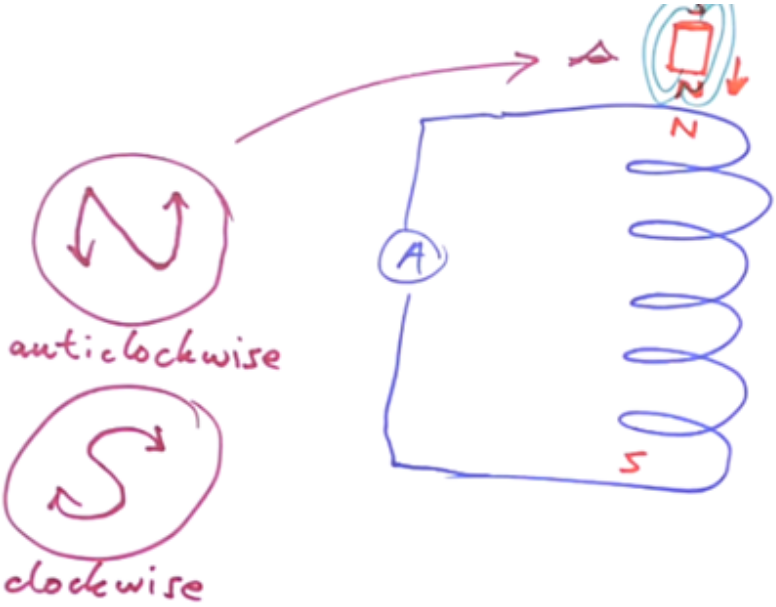
Where…
- P = pressure (Pa)
- V = volume (m^3)
- T = temperature (K)
- n = number of moles
- N = number of molecules
- R = universal gas constant = 8.3145 $Jmol^{-1}K^{-1}$
- k_B = Boltzmann's constant = 1.38 x 10^{-23} JK^{-1}
- N_A = Avagadro's number = 6.023 x 10^{23} mol^{-1}

This is formed by combining all 3 gas laws to form a constant of $PV \propto T$ which becomes $PV \propto NT$ as with more molecules, we have greater pressure and then we introduce a constant. This constant is good for proportionality questions.

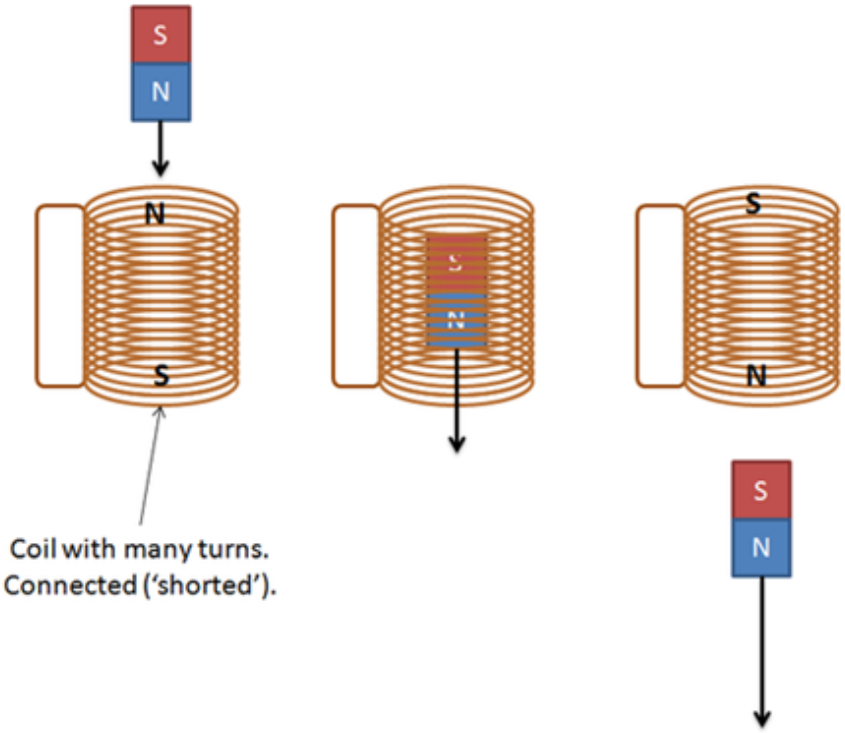
---

296. What happens when a bar magnet falls through a solenoid?

1. A bar magnet falling north-first will induce a current in the solenoid producing a magnet field that **opposes the motion** of the bar magnet thus slowing it down (Lenz's Law).
2. The current flows counterclockwise looking down.
3. It flips direction half-way through.
4. When exiting south-last, there is a north pole at the bottom and a south pole at the top **opposing the motion** again.
5. The current flows in the opposite direction.



Shown also…



This is to prevent acceleration and thus 'free' energy.

297. How can nuclear radius be determined by closest approach?

Fire alpha particles of increasing kinetic energy towards a nucleus. They will transfer their KE into PE as they approach (2 positives moving to each other) and at one point, they will no longer return.
Loss in KE = Gain in PE as shown:

$$E_K = E_P$$

$$E_K = \frac{1}{4\pi\epsilon_0} \cdot \frac{Q_\alpha Q_n}{r}$$

$$r = \frac{1}{4\pi\epsilon_0} \cdot \frac{Q_\alpha Q_n}{E_K}$$

NOTE THAT BOTH CHARGES MATTER HERE!
This kinetic energy of an electron relies on v << c in $E_K = ½ mv^2$.

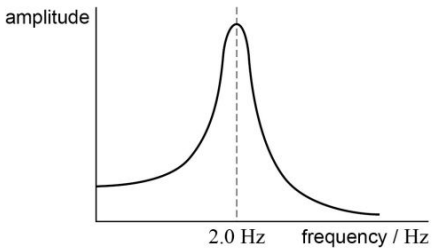
---

298. How have observations of Type 1a Supernovae led to the conclusion that the universe's expansion is accelerating? Why is this controversial?

- Supernovae that reach a known **PEAK** luminosity. Using the known absolute magnitude and the observed apparent magnitude in the equation, we calculate a distance.
- Data doesn't fit with Hubble's Law suggesting accelerated expansion. Controversial as... no known energy source for expansion.

---

299. How will a mass-spring system differ when submerged in oil? Why?



1. Max amplitude will be lower (1) due to energy losses (1)
2. Peak broader (1) due to damping (1)

---

300. Give 2 examples of mesons

-Pions (π^+, π^-., and π^0).
-Kaons (k^+, k^-, and k^0).

---

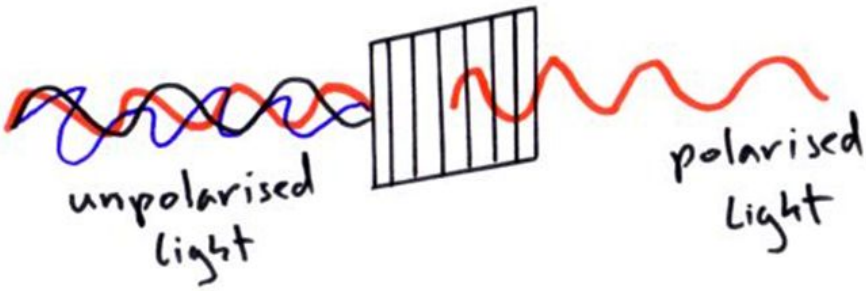
301. What is wavelength?

The distance between two identical consecutive points on a wave.

---

302. How can you make a wave polarised, what does this do, and how does it work?

- By passing it through a polaroid filter **WHICH ALLOWS** waves oscillating in one plane to pass **LOWERING** the new wave's intensity.
- Oscillations in the other directions are absorbed by the molecules.



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303. What is the equation for determining the width of the central fringe?

This isn't in the formula book.

$$W = \frac{2\lambda D}{a}$$

*Where **W** is the width of the central maximum, **D** is the distance between the single slit, **a** is the length of the opening of the single slit.*

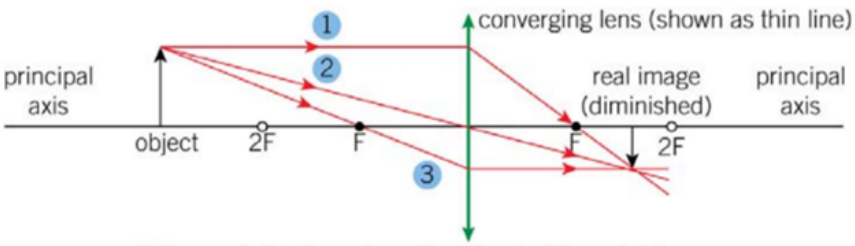
---

304. Why does 'low intensity EM radiation (above f_0) resulting in immediate emission of electrons' support the particle theory over the wave theory?

- Wave theory - energy ∝ intensity ∴ lower intensity means it must take time for energy to accumulate to free an electron.
- Particle theory - no. of electrons emitted ∝ intensity ∴ whilst few arrive for low intensity, they still have sufficient energy ⇒ immediate electron emission.

---

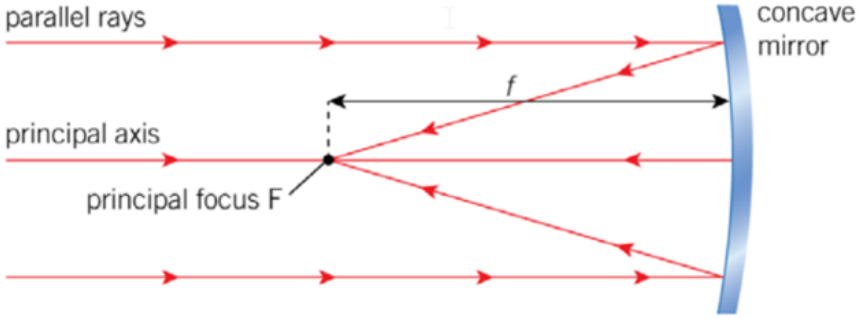
305. What is the ray diagram for object lying between principal focus and infinity? How does the image appear?



Real, diminished, and inverted.

306. Describe a simple reflecting telescope

-Uses concave mirror to act as objective / primary mirror.
-A secondary smaller mirror reflects light from the primary onto an eyepiece.
-Principal axis is normal to centre of concave mirror.



Rays parallel to the principal axis meet at the principal focus. All others are reflected to another point on the focal plane.

307. Compare refractors and reflectors

Reflectors	Refractors
Easier to manufacture large concave mirrors allowed for more light.	No secondary mirror to block out light.
Shorter than refractors with same angular magnification.	Wider field of view with less ∵ angular magnification ∴ finds more objects more easily.
Leads to spherical aberration (∵ reflection).	Wide lenses (required to match reflectors) would make top-heavy telescopes ∴ difficult to support.
	Leads to chromatic aberration (∵ refraction.)

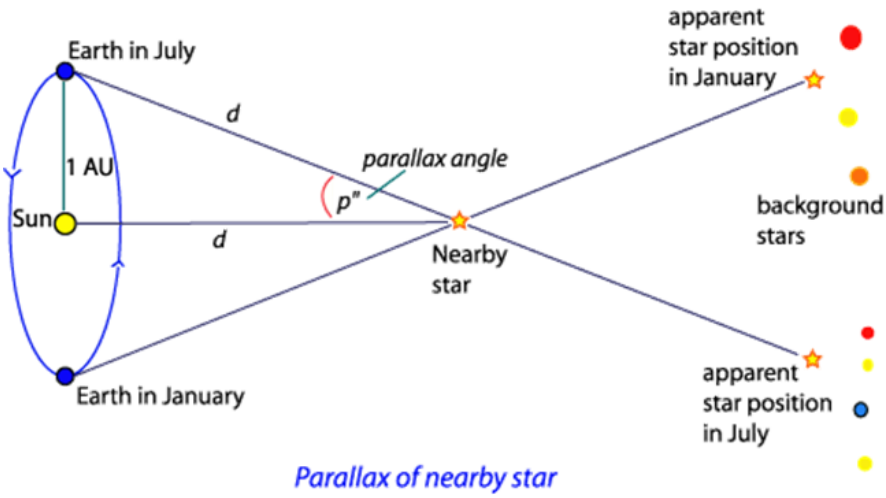
- Reflectors blocks some light and diffracts it around the secondary mirror too.

308. How can diffraction in telescopes affect image resolutions?

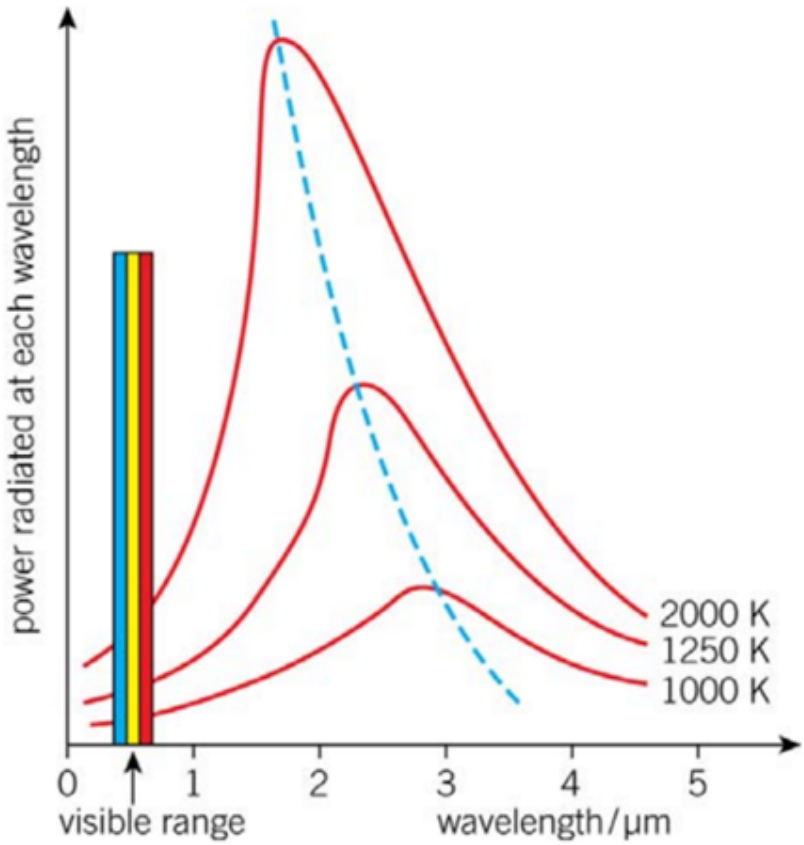
Due to diffraction of light, a small objective cannot resolve two objects. *This is less important for x-rays / gamma ray telescopes due to the wave's small wavelength.*

309. What is 1 pc defined as?

-1 pc is the “the distance at which 1 AU subtends an angle of 1/3600th a degree”.
-Using d ≈ r / theta from the diagram below, 1 pc = 1 AU / (1 degree in arcseconds).



310. Draw the black body radiation curve / spectra of stars for different temperatures



The peak of the graph move towards shorter wavelengths as the temperature increases.
Be careful when looking at the shift.
It has to be steeper on one side than the other.

311. When does a star become a white dwarf?

When the remaining core mass ≤ $1.4m_{sun}$ after first becoming a red giant.
It cannot fuse anymore and its outer layers are thrown off in shells called a planetary nebulae.

312. What is recessional velocity?

The rate at which an astronomical object is moving away, typically from Earth.

313. What are quasars thought to be? How do they relate to blackholes and galaxies?

- Fast-moving clouds of gas/matter.
- They are emitted by black holes at the centre of galaxies.

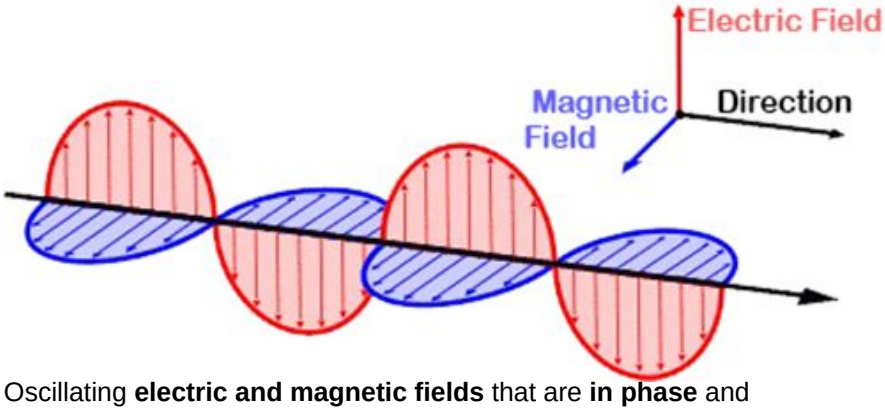
314. Give 3 properties of gamma rays

-High frequency.
-Very penetrating.
-Not so ionising.

315. How can you tell if something is weak interaction?

1) It will involve hadrons and leptops.
2) Strageness won't be conserved.

316. What are electromagnetic waves?



Oscillating **electric and magnetic fields** that are **in phase** and **perpendicular** to one another.

317. What are readings and measurements and the absolute uncertainty of both? Why? To what dp should they be given?

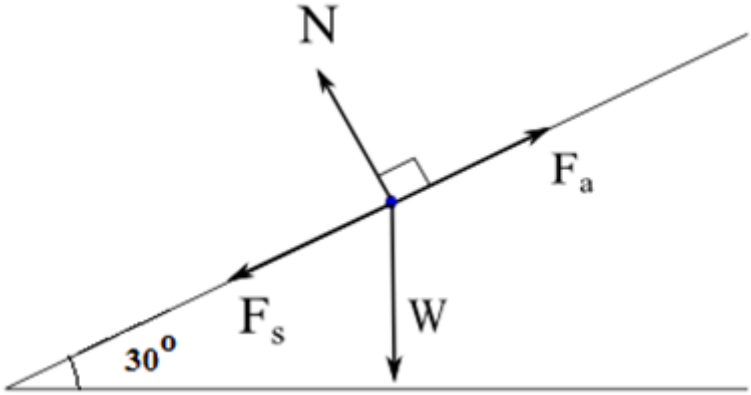
Readings…
- Absolute uncertainty is ½ resolution.
- No zero error because you're not lining things up (e.g., thermometers, measuring cylinders).

Measurements…
- Absolute uncertainty is the resolution.
- Zero error because you're lining up with zero (e.g., ruler, stopwatch, micrometer, vernier callipers).

They should be to no greater no. of decimal places than the value it is for. E.g., if you calculate the uncertainty for 0.29mm to be 0.0081mm then it must be 0.01mm.

318. When is an object in equilibrium?

When there is **NO RESULTANT FORCE** (hence closed triangle) and **NO RESULTANT MOMENT**.
*Thus when ≥ 3 forces act on a body in equilibrium, the resultant of all but one will be **equal and opposite** to the last. Similarly, the sum horizontal and vertical components of all forces is 0.*



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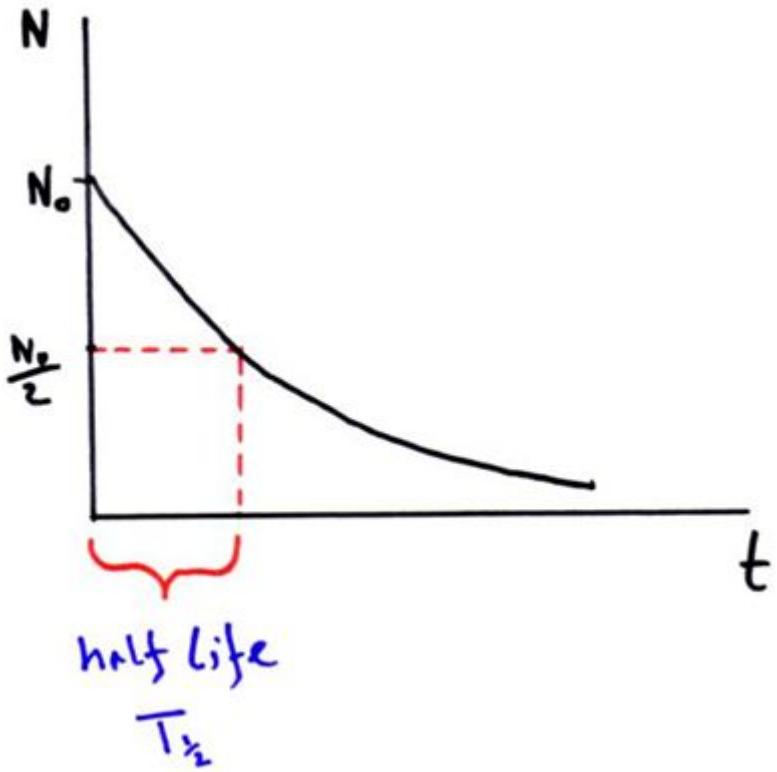
319. What are the pros and cons of a CCD compared to the eye?

+Quantum efficiency of > 80% compared to eye's 1% (∴ can see fainter objects)
+Can record faster-changing images than the eye
+Sensitive to more wavelengths than the eye
-CCD is more expensive than normal cameras
-CCD has to be supercooled

---

320. What is the half-life of sample?

The half-life is the time for half the nuclei to decay.



Which can also be given by the following equation:

$$T_{1/2} = \frac{\ln 2}{\lambda}$$

Which can be derived from the following:

$$N = N_0 e^{-\lambda t}$$

---

321. Why can an electron not follow a circular path when moving at right angles to a uniform electric field? What instead is required?

- As it will accelerate in the direction of the field.
- It must move at right angles to a uniform mangetic field.

---

322. What are the 7 SI base units?

- length - **metres** (m)
- mass - **kilograms** (kg)
- time - **seconds** (s)
- current - **amperes** (A)
- temperature - **kelvin** (K)
- amount of substance - **mole** (mol)
- luminous intensity - **candela** (cd)

---

323. What is gravity and its force carrier?

The mechanism by which particles with mass attract each other by exchanging gravitons.

---

324. What's the difference between excitation with electrons and photons? Why?

-An **electron** can **have more energy** (e.g., a 5.3 eV electron colliding with and moving another electron up by 4.9 eV before carrying on with 0.4 eV).
-A **photon** has to **deliver** the **exact amount** (e.g., exactly 4.9 eV) as it's energy is absorbed in a 1-to-1 interaction.
- Since electrons in the atom are in discrete energy levels.
Interesting to note an electron still needs a minimum energy to just approach and not get repelled.

---

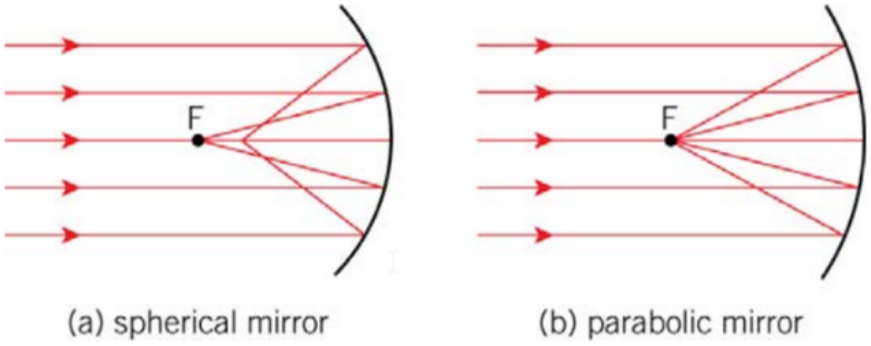
325. What is natural frequency and driving frequency?

-Natural frequency is the frequency at which the molecules of an object vibrate at naturally.
-Driving frequency is the frequency of the periodic force.

---

326. What is spherical aberration? How is it solved?

-When the outer rays are brought to focus a nearer the focal point leading to distortion.
-Solved by using a parabolic mirror in telescopes.



This is because the angle of incidence = angle of reflection.

---

327. What are Balmer Lines and when are they seen?

-Absorption lines due to transition from n = 2 to a higher energy level in an hydrogen atom.
-They are only seen in hot stars - specifically B, A spectral classes - in the visible spectrum.
Hydrogen atoms from the n = 1 ground state do not absorb visible photons since the energy required is too large.

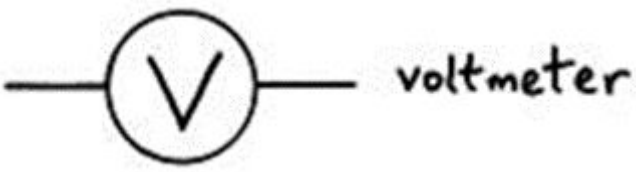
---

328. What is the likely cause of a Gamma-Ray Burst?

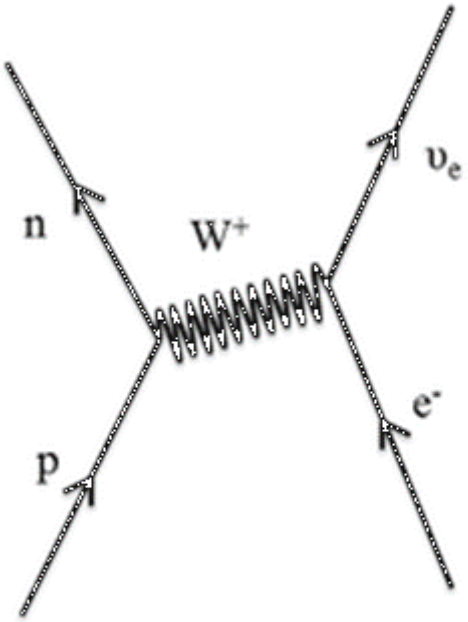
The collapse of a massive star into a neutron star / black hole.

---

329. What is the circuit symbol of a voltmeter?



330. What is the Feynman Diagram for electron capture?



$$p + e^- \rightarrow n + \upsilon_e$$

An electron from an inner shell is captured by a proton in the nucleus and exchanges a W^- boson with a proton to form a neutron and an electron neutrino.
This is because the nucleus has too many protons yet not enough neutrons.

331. What are the sections of the electromagnetic spectrum and the properties of either side?

Name	Properties
Radio	Longest wavelength ⇒ lowest frequency ⇒ least penetrating.
Microwaves, Infrared, Visible, Ultraviolet, X-ray	
Gamma	Shortest wavelength ⇒ highest frequency ⇒ most penetrating.

Remember My Instructions, Visible Under X-Ray Glasses.

332. What is absolute refractive index?

How many times slower the **speed of light** is in a **medium** compared to the speed of light in a **vacuum**.

$$n = \frac{c}{c_s}$$

c_s is the speed of light in the substance.

---

333. What is each variable in the equation for Young's Double Slit?

$$w = \frac{\lambda D}{s}$$

w is fringe spacing (m), **D** is distance between the double slits and the screen, **s** is the split separation (m).

---

334. What is phase difference for both stationary and progressive waves?

- For standing waves, the phase difference can only ever be π/2, π, 3π/2 or 2π radians.
- For progressive waves, the phase difference is the fraction of a cycle between the two vibrating particles. Hence, (distance between points) / (wavelength) * 2π.

This is the case for progressive waves because each point will undergo maximum displacement from equilibrium position. The two points will always remain however much out of phase when the wave passes through them (imagine them being an equal distance apart constantly on a circle). Or the same hand on two different clocks. It isn't possible to measure the phase difference between the minute hand on one and the hour on the other because of difference frequencies.

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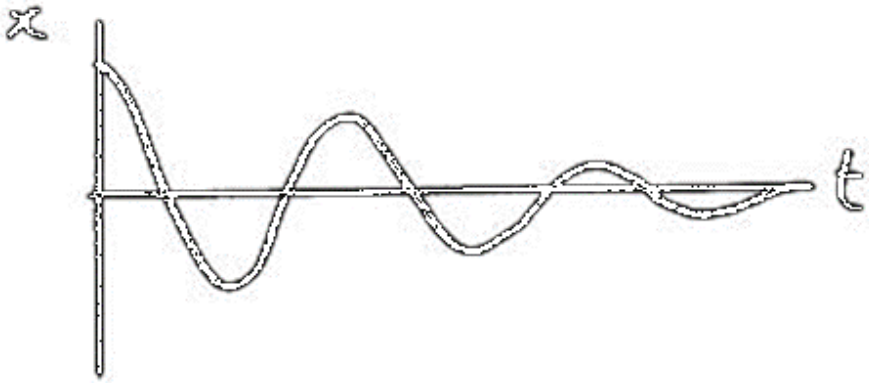
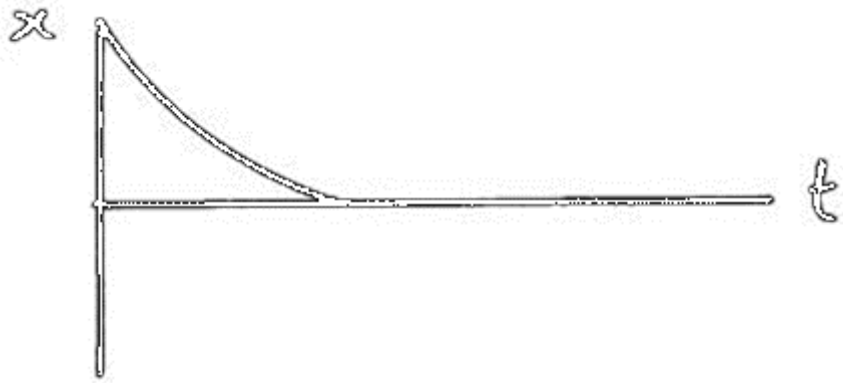
335. What are the 3 types of damping with their associated graphs?

-Light damping:



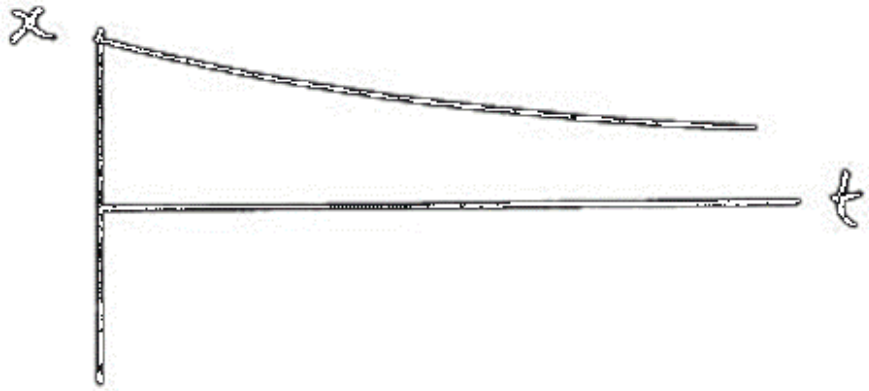
Reduces by the same fraction each cycle, more of less.

-Critical damping:



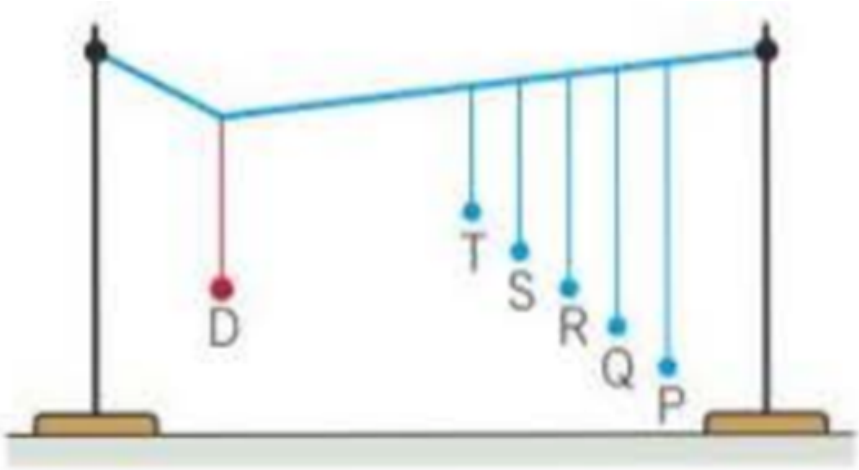
Used more often as it's more comfortable (eg vehicle suspension systems).

-Overdamping:



The damping force is so strong that the displaced object will return to equilibrium much more slowly (imagine it going in the opposite direction too).

336. What are Barton's pendulums?



A set up where D is a forced oscillator to which R responds the most by having amplitude.

---

337. What assumption is made in the Electric Field Strength equations?

- You're using a small charge, otherwise, it'll affect the position of the larger object and thus the position of itself in the field.

---

338. When will a charged particle experience no mangetic force in a magnetic field?

1. When moving parallel to the field.
2. When at rest.

---

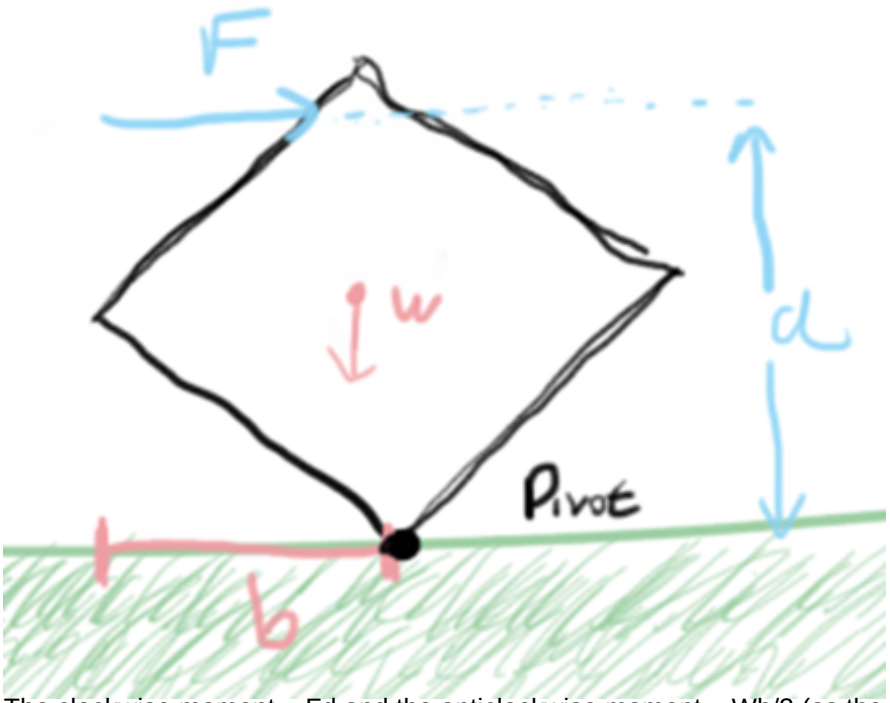
339. What is unpolarised light?

A mixture of waves oscillating in different planes.

---

340. When will an object rotate and topple (with an example)?

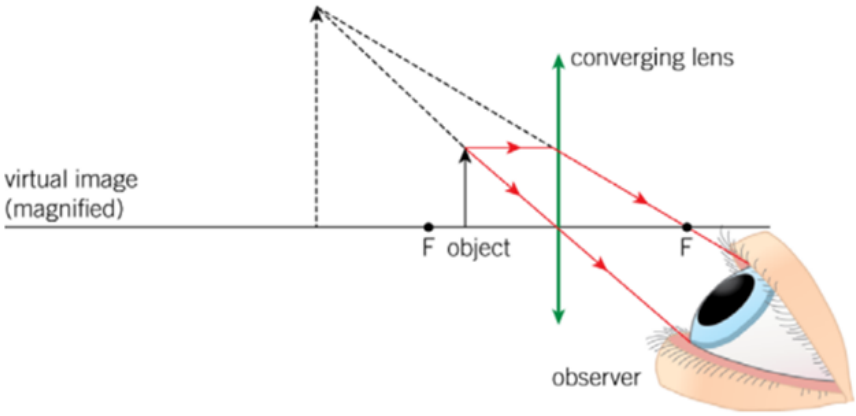
- It rotates when there is a resultant moment acting on it.
- It topples when the centre of mass acts outside the base.



The clockwise moment = Fd and the anticlockwise moment = Wb/2 (as the weight is in the middle).

341.	What happens in elastic, inelastic, and perfectly inelastic collisions?	- Elastic is when **BOTH** momentum and kinetic energy **IS** conserved. - Inelastic is when momentum **IS** conserved **YET** kinetic energy **IS NOT**. - Perfectly inelastic is where the colliding objects stick.
342.	What is required for circular motion in a roller-coaster loop?	To have a velocity greater than the minimum velocity all the way through the loop.
343.	What is Specific Latent Heat?	The energy required to change the state of 1 kg of material without changing temperature. *As the energy is going into breaking bonds, not changing temperature.*
344.	What is pulse absorption and how is it minimised?	- Less transparent a material, more light is absorbed so the shorter a pulse with given energy can travel. - It's minimised by using a very pure transparent material in optical fibres. *A given fraction of a pulse is absorbed per unit distance so it follows an exponential decay. The more transparent, the lower the decay rate.*
345.	How can you work out how many times brighter one star is to another?	By using... $100^{\frac{m_1-m_2}{5}} = 2.51^{m_1-m_2}$
346.	Define threshold frequency (f_0) under the photoelectric effect	Minimum frequency required to overcome the work function causing emission of e^-'s.
347.	Above 3 fm, the **[...]** drops and the **[...]** takes over ∴ **[...]**.	Above 3 fm, the **strength of the strong nuclear force** drops and the **strength of the electrostatic force** takes over ∴ **decreased stability**.
348.	What is Newton's Second Law of Motion?	"The resultant force is proportional to the rate of change of momentum and **acts in the same direction as the change in momentum**." $F = \frac{\Delta(mv)}{\Delta t}$ *F = ma is a special case of where mass is constant. This cannot be used for a rocket.* *Remember that the change in momentum has to be constant. E.g., going from 5 $kgms^{-1}$ to 0 $kgms^{-1}$ exerts some force whose size is dependent on the time in which this change occurs. Thus cushions work better than harder surfaces such as steel.*

349. What is the ray diagram and image for object lying between principal focus and lens?



Virtual, magnified, and upright.
This is essentially a magnifying glass.

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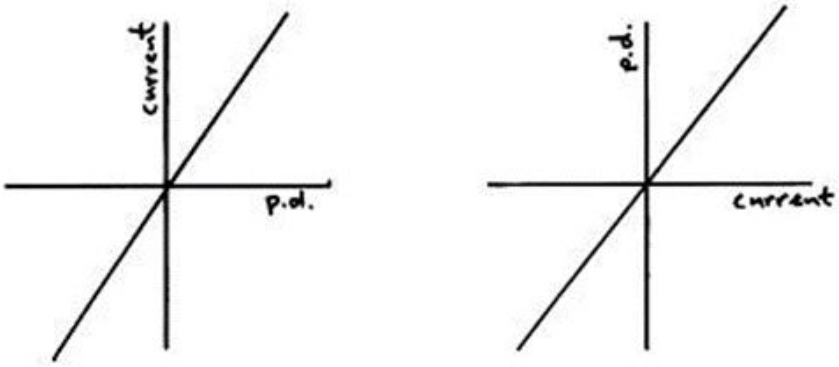
350. Give an example of an ohmic conductor with its current-voltage graph

A resistor at constant temperature.



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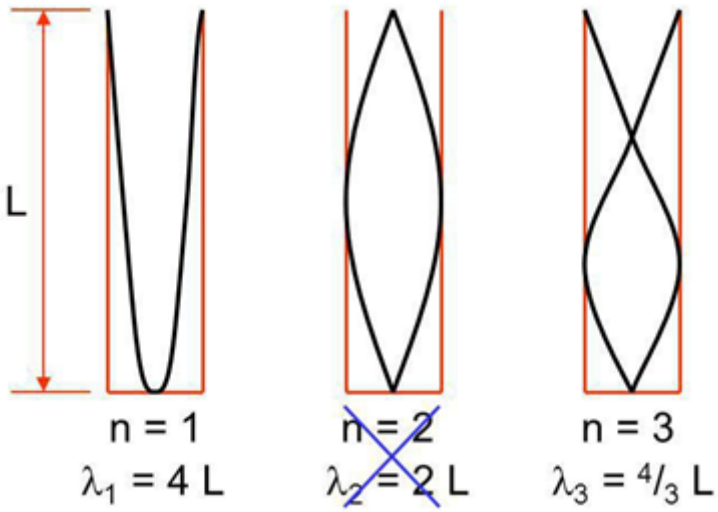
351. What is the length of each harmonic for a tube closed at one end?

- At the 1st harmonic, l = λ/4.
- At the 3rd harmonic, l = 3λ/4.
- At (2n - 1)th harmonic, l = (2n - 1) * λ/4.

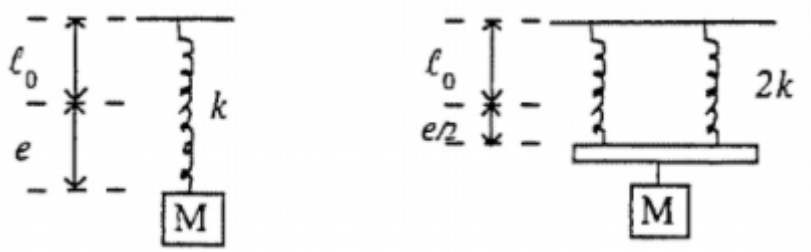
Only the odd numbered harmonics exist.



352. How does Hooke's Law work on springs in parallel and why?

$$k_T = k_1 + k_2$$

The same force of Mg is shared between both springs ⇒ extension on each is ½ the original ⇒ spring constant has to be 2k.



On the load-extension graph, you're getting half the extension for the same force so the line is steeper. You can think of this as using muscle building equipment using multiple parallel springs, the more springs, the harder it is to compress (and hence stiffer).

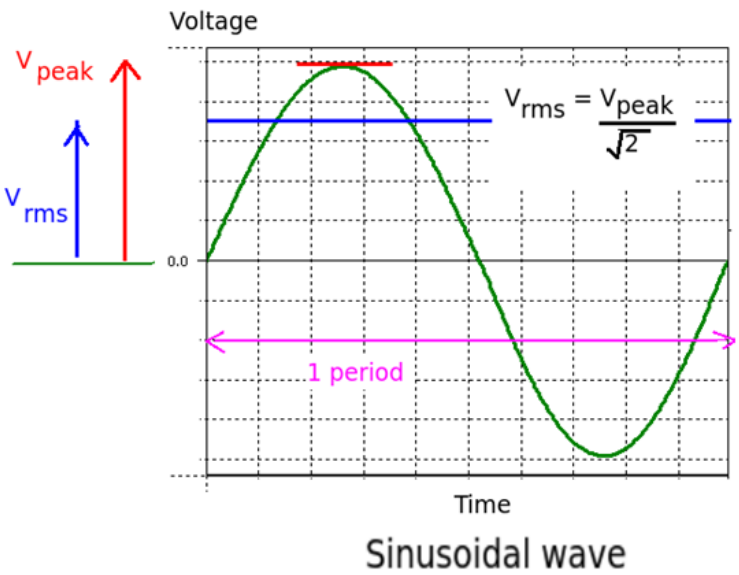
---

353. What assumptions are made in the molecular kinetic theory?

R - random motion (random speeds with no preferred direction of motion)
A - no attraction between particles.
V - particles have negligible volume compared to container.
E - elastic collisions so E_k is conserved.
D - duration of collisions << time between them.

---

354. What is RMS Voltage?

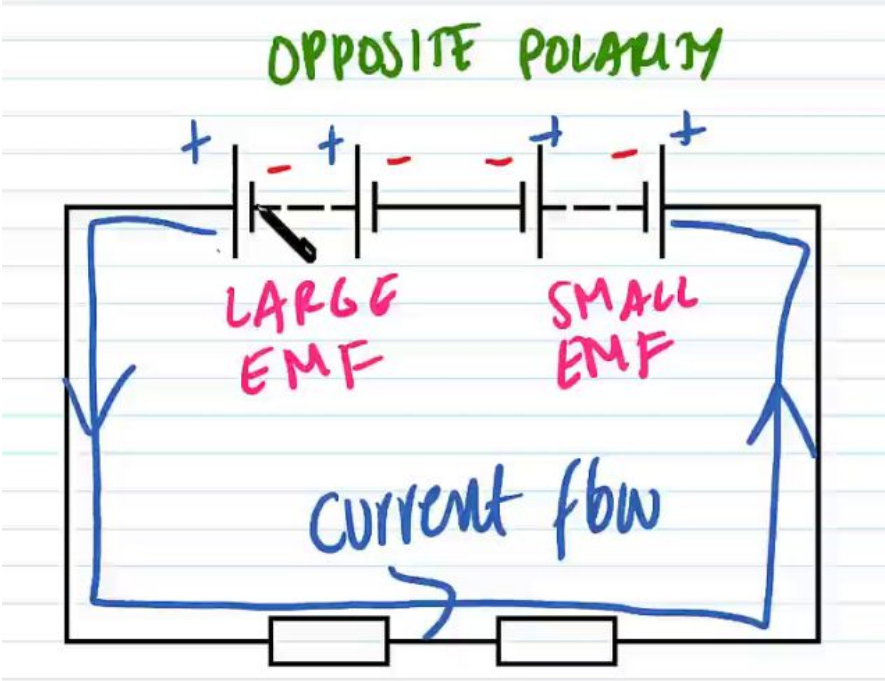


- This is the DC Equivalent of the AC voltage.
- The sine wave in the UK is 50 HZ.

---

355. How do e.m.f sources in opposite polarities work?

- Current will flow from the positive to negative terminal of the source with the largest emf.
- The source acting in opposite reduces the total emf.



356. Why is there an iron core in a transformer?

To direct the magnetic field round to the secondary coil.

357. What are lasers sources of?

Coherent, monochromatic light.

358. What are brittle and malleable materials?

Brittle materials don't stretch far beyond their elastic limit. They break. Malleable materials will stretch far.

359. What is centripetal force and what would happen without it?

-A resultant force (e.g., weight, friction, gravity) acting towards the centre of a circle providing **CONSTANT** acceleration.
-Without it, by Newton's First Law, the object would fly off tangentially.
Since it's not a force itself, it should never be drawn on a free body diagram.

360. What are the 4 fundamental forces?

1.Gravity.
2.Electromagnetic force.
3.Strong nuclear force.
4.Weak nuclear force.

361. How should it look like when working out which particle should be used?

$$\bar{\nu}_\mu + p \rightarrow n + e^+$$

L:	$(-1) + 0 = 0 + (-1)$	no problem
L_μ:	$(-1) + 0 = 0 + 0$	problem
L_e:	$0 + 0 = 0 + (-1)$	problem

---

362. What is a black body?

A perfect absorber of radiation (absorbing 100% of incident radiation at all wavelengths) thus emitting a continuous spectrum of wavelengths.
Recall from GCSE that a matt black surface is the best absorber and emitter of infrared radiation.

---

363. What are neutron stars?

Relatively small and very dense stars made up of neutrons.

---

364. How can you calculate RMS velocity?

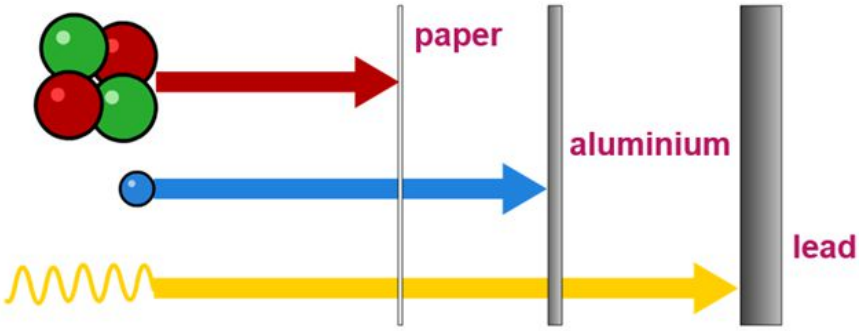
$$c_{rms} = \left[\frac{(c_1^2 + c_2^2 + \ldots + c_N^2)}{N} \right]^{1/2}$$

*We call this the average speed. The average **VELOCITY** is zero since we have equal number of molecules travelling in opposite directions.*

---

365. How does α, β and γ radiation vary in penetration?

1.Alpha particles are stopped by a few cm of air / thin sheet of paper.
2.Beta particles are stopped by a few mm of aluminium.
3.Gamma ray intensity is halved by 10 cm of lead.



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366. What is Kirchhoff's First Law?

"At any junction, the sum of the currents entering = the sum of the currents leaving."
This is fundamentally a statement about the conservation of charge.

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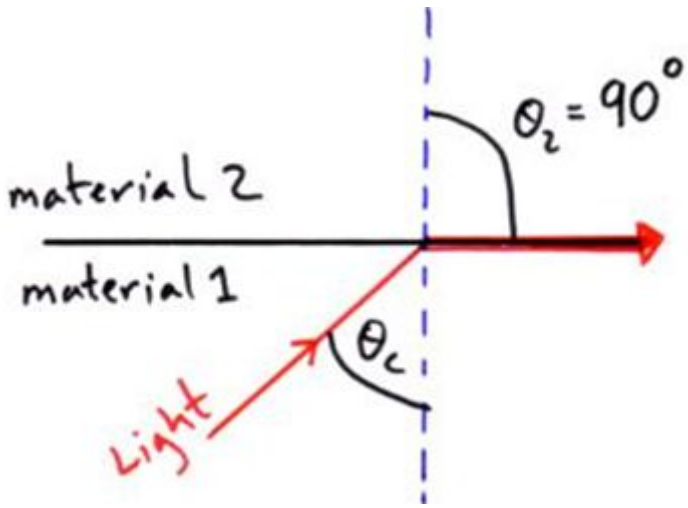
367. What happens when the incident angle = the critical angle?

The **angle of refraction** is **90°** (so travels along the boundary).



368. Give 3 characteristics of quasars

1. Very powerful light output (>> than our Sun).
2. Relatively small size (≈ size of our solar system).
3. Large redshift.

369. What 3 ways can (exo-)planets be detected and their disadvantages?

1.Radial velocity method:
■Look for a periodic shift in wavelength from a star wobbling around its barycentre.
-Only works for large planets close to their star.
-Other planets can cancel out their motion
2.Transit photometry:
■Look for regular dips in intensity of a star caused by a planet passing.
-Only works for planets close to their star and in the line of sight of Earth.
3.Direct observation:
- The star is much brighter than the light reflected by the planet.
- The angle subtended by the planet is too small.

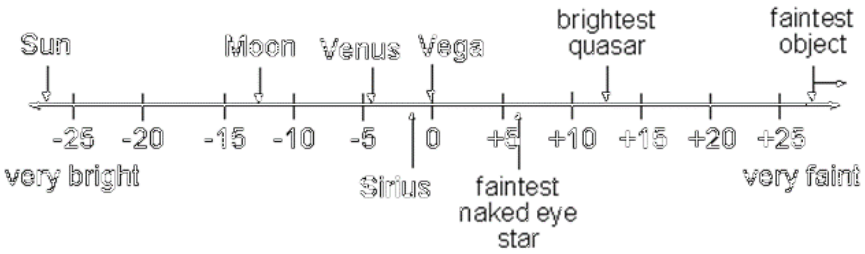
370. What is the dynamo effect?

●Force produces a current JUST LIKE current produces a force.
●It tries to stop the motor effect.
●Eg, when a motor turns then it also produces the Dynamo Effect due to Lenz's Law
This is from many symmetries in physics. It works both ways.

371. Why must mercury gas be at a low pressure in fluorescent lights?

- Electrons must be able to travel a sufficient distance to gain sufficient energy required for excitations (1).
- Electrons need to be able to pass through.

372. Describe the star magnitude scale



Apparent brightnesses of some objects in the magnitude system.

- Hipparcos Scale assumed brightest stars have mangitude 1 and dimmest 6 with 1 being 100x brighter than 6.
- Applying it now means some stars have negative apparent magnitude.

---

373. What are pulsars?

Neutrons stars that emit radio waves in two beams as they rotate.

---

374. What is the De Broglie wavelength?

The wavelength of matter.

---

375. Give 2 advantages and 1 disadvantage of optical fibres compared to metal wires

+ They don't corrode
+ They can send more information per second.
- Difficult to join fibres and make junctions.

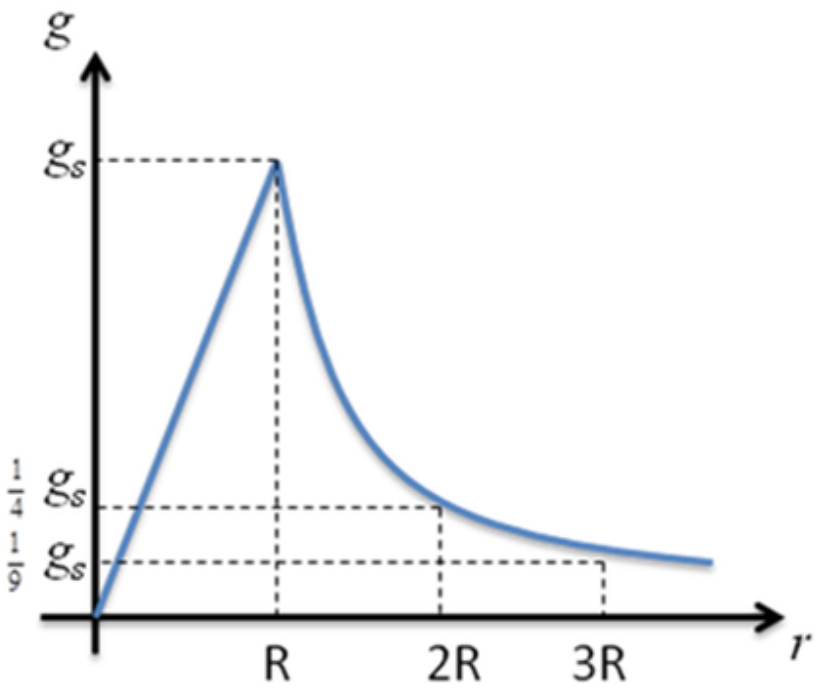
---

376. What is a moment defined as?

A force multiplied by the perpendicular distance between the pivot and the **line of action** of the force.
In essence, we're looking at the turning effect of a force. When we take moments about a point, we can ignore the force acting at the point. So never pick a point where you'd have to consider all distances and forces.

---

377. What does the Gravitational Field Strength v. Distance graph look like and why?



The linear relationship at the start is because the mass below you is what matters (between the centre and r). By combining $g=GM/r^2$ and $M = 4/3 * \pi r^3 p$, you get a linear relationship of $g=4/3 * \pi Gpr$.

378. Why is SHM only a good approximation for a pendulum at small angles?

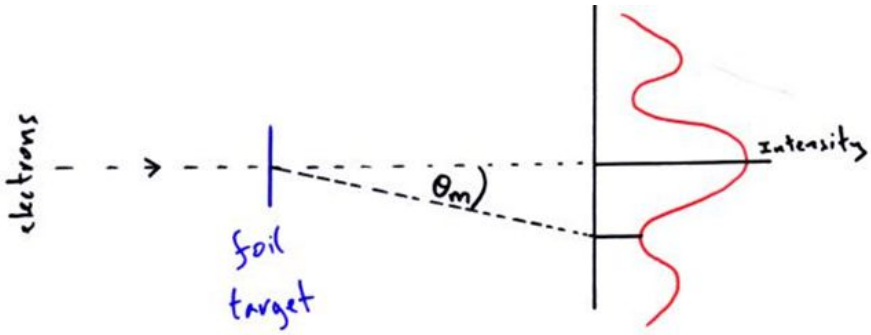
As the displacement (straight line path) is close enough to the curved path (until about 10°).

379. Where does background radiation come from? (both natural and man-made)

Natural:
1.Cosmic rays.
2.Natural radioactive material in rocks / soil.
3.Radon gas.
Man-made:
1.Medical sources.
2.Nuclear power stations.
3.Nuclear tests.

380. Describe how electron diffraction is used to determine the nuclear radius. Why is this better?

- Electrons are directed at a foil target of the atom whose radius is to be determined.
- As electrons are leptons, they don't experience the strong interaction (whereas alpha particles, used to determine radius by closest approach).
- A diagram of this is shown below:



The intensity isn't 0 at the first minima because some electrons still manage to reach it.
The first minimum θ_m is used in the following equation (which you don't need to know):

$$r = \frac{0.61\lambda}{\sin\theta_m}$$

Where λ is the DeBroglie wavelength of an electron. The 0.61 reflects the fact this is a 'circular aperture'.

381. What is resistance caused by?

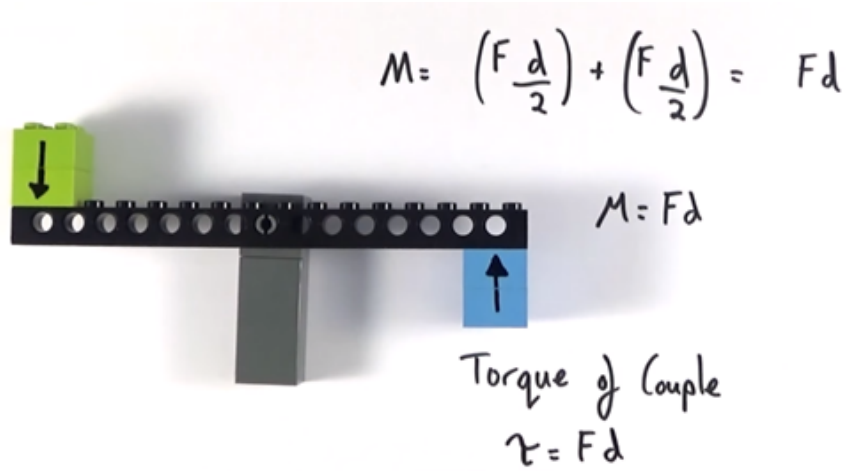
The repeated collisions between the charge carriers and positive ions.

382. What is an electron volt defined as?

The energy of an electron when accelerated through a p.d. of 1 V.

383. What is a couple defined as and how can it be calculated?

- A pair of equal and opposite coplanar forces.
- Force × perpendicular distance between the lines of action of the forces.



As shown, it can be calculated by taking moments about the centre. Since the system isn't in equilibrium (as there's a resultant moment), you cannot use the principle of moments.

384. Why is pulse broadening bad?

Leads to a less coherent signal.

385. What 4 things does the force exerted in the motor effect depend on?

1.The current in the wire and its direction.
2.Strength of the magnetic field.
3.Length of the wire.
4.Angle of the wire/current relative to the magnetic field lines.
The greatest force is experience when the wire is perpendicular to the field. No force is experienced when parallel.

386. What is current ∝ to under constant resistance and why?

The **emf** of the battery ■ the **more energy** supplied to the charge carriers, the **faster** they will move.

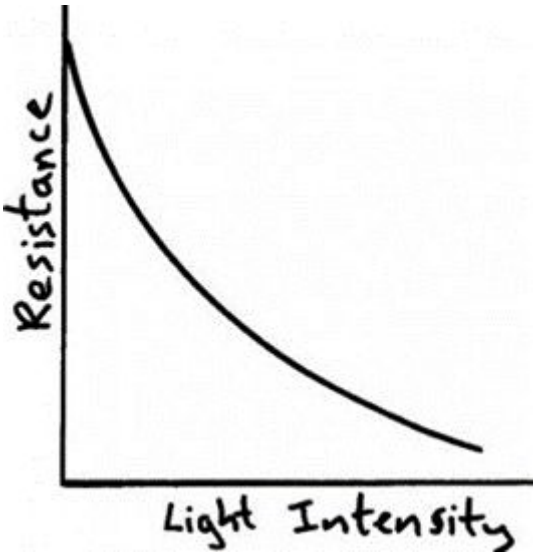
Remember that current is the rate of the flow of charge.

387. Why is resistivity useful?

It allows resistances of **different materials** to be **compared** when under the **same physical conditions**.

388. What happens to a LDR as light intensity changes?

Its **resistance decreases** as its **light intensity increases**.



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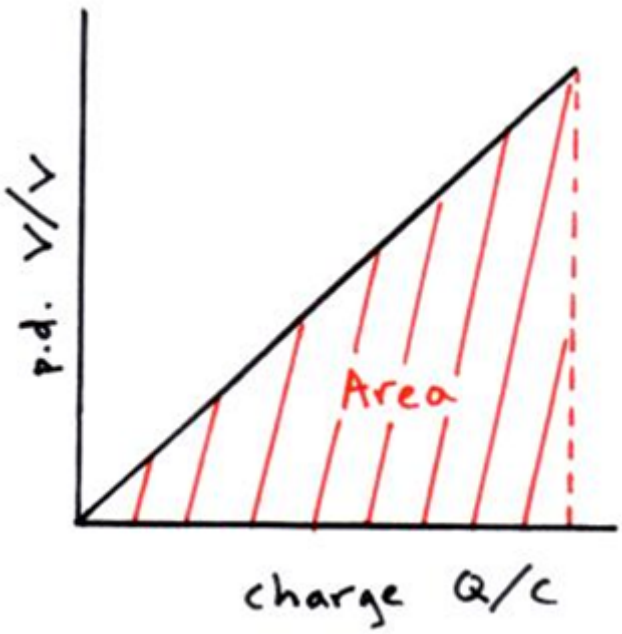
389. What problems do beta minus and beta plus decay solve?

- Beta minus decays solves too many neutrons.
- Beta plus decay solves too many protons.

---

390. Derive the equation for the energy stored in a capacitor

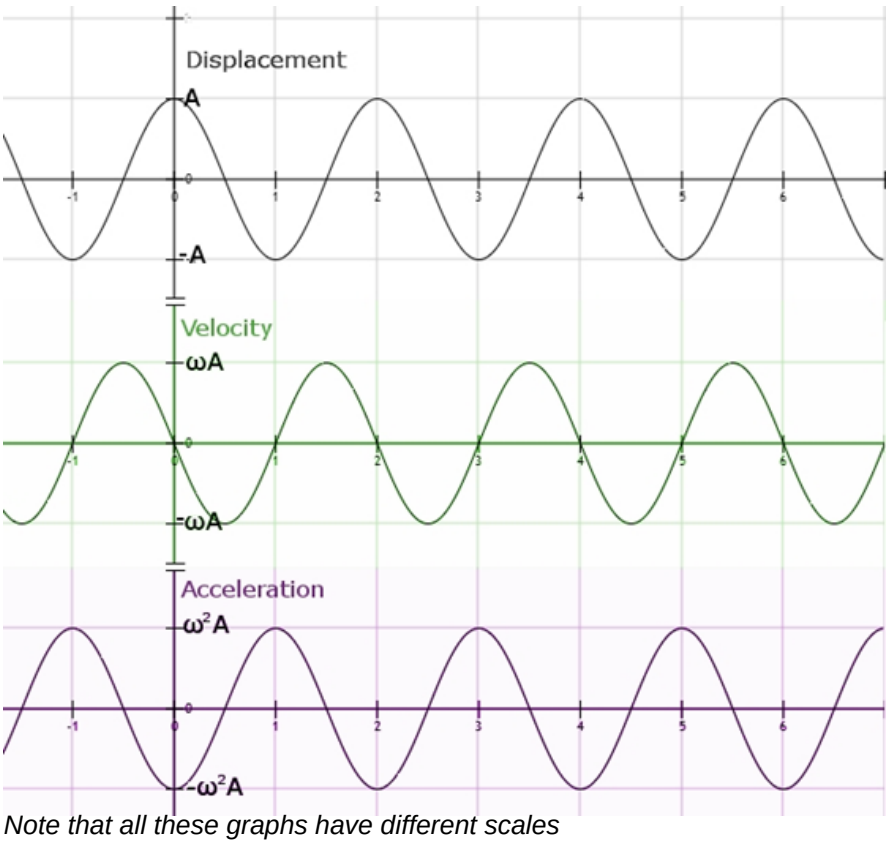


$$E = \frac{1}{2}QV = \frac{1}{2}CV^2 = \frac{1}{2}\frac{Q^2}{C}$$

Half the energy is 'lost' under resistance. There is no way around this.

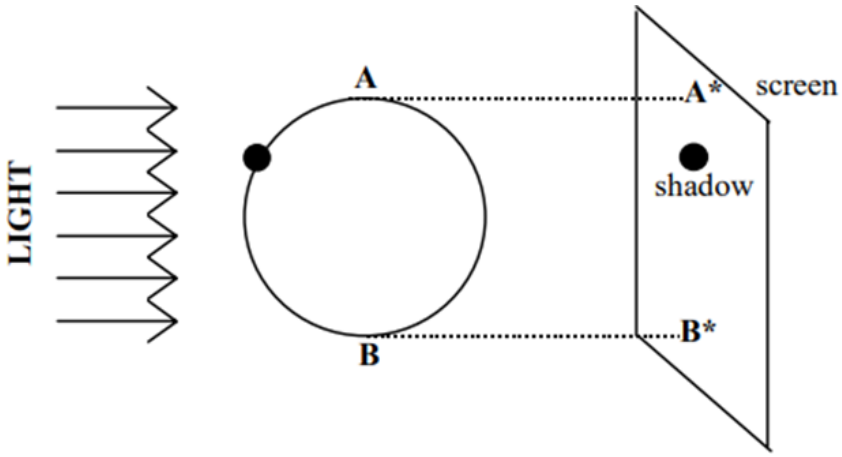
---

391. What do the displacement, velocity, and acceleration graphs for SHM look like?



Note that all these graphs have different scales

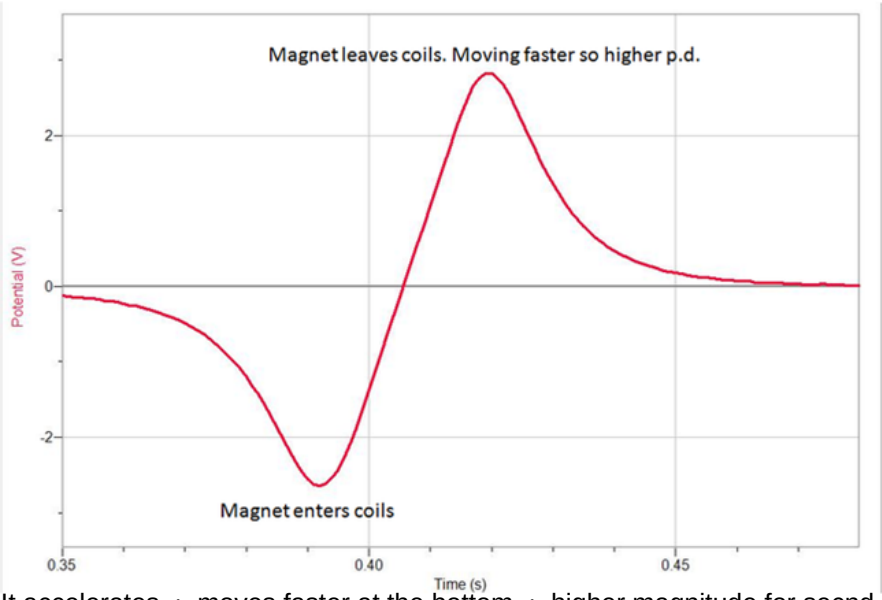
392. What is the link between SHM and circular motion?



393. What is Specific Heat Capacity?

The energy required to raise the temperature of 1 kg of a substance by 1 K.

394. How does the p.d. v. time graph look like for a magnet falling via a solenoid?



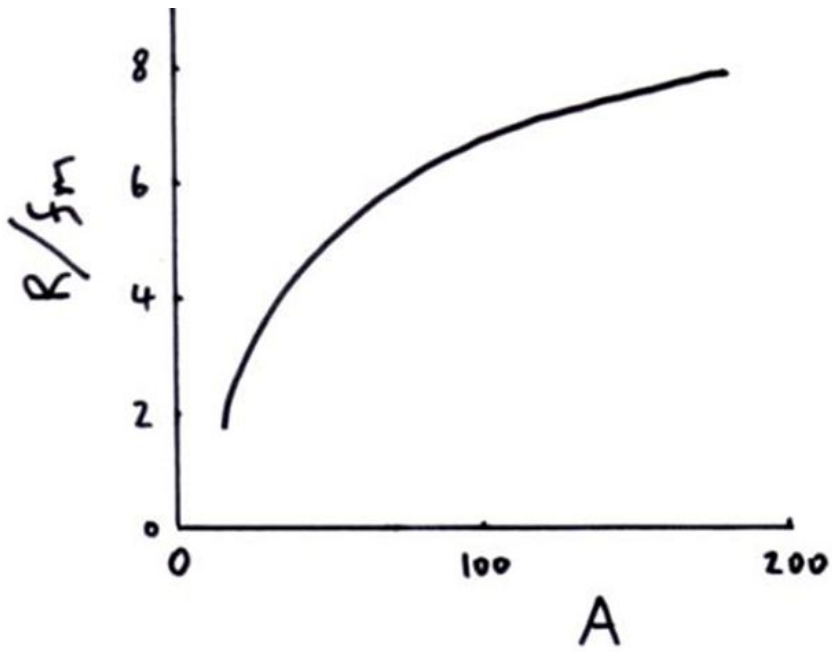
It accelerates ∴ moves faster at the bottom ∴ higher magnitude for secnd peak.

---

395. How is the approximate nuclear radius and nucleon number related?

$$R = r_0 A^{1/3}$$

Where R is the nuclear radius (m), r0 is the radius of a nucleon, approximately 1.3 fm, and A is the nucleon number.
This is based on the following experimental data:



396.	What happens to both insulators and conductors when a voltage is applied across them and why?	- In **insulators**, **no current passes** ■ electrons are **fixed**. - In **metallic conductors**, **current passes** ■ some electrons are **delocalised** (i.e., the charge carriers).
397.	What can you view the spectrum of a light source using?	A diffraction grating and spectrometer.
398.	What is potential gradient?	-By how much the Gravitational/Electric Potential changes per metre. $$\text{Potential gradient} = \frac{\Delta V}{\Delta r}$$ *E.g., 9.81 $Jkg^{-1}m^{-1}$ near the surface.*
399.	What is a synchronous orbit and a geostationary orbit?	-A synchronous orbit is where the orbital period of the satellite is the same as the rotational period of the planet. -A geostationary orbit is synchronous orbit around Earth's equator (thus 24 hours).

400. Derive the equation for the total energy of an satellite

$$F_{cp} = F_{grav}$$
$$v^2 = \frac{GM}{r}$$

$$\begin{aligned} E_T &= E_K + E_G \\ &= \frac{1}{2}mv^2 - \frac{GMm}{r} \\ &= \frac{GMm}{2r} - \frac{GMm}{r} \\ &= -\frac{GMm}{2r} \end{aligned}$$

Negative energy is used to help account for the conservation of energy. Imagine two masses in a vacuum, as they accelerate towards each other in a vacuum, both kinetic energy and gravitational potential energy increases. Yet, the net energy must be zero so we must make gravitational potential energy negative.

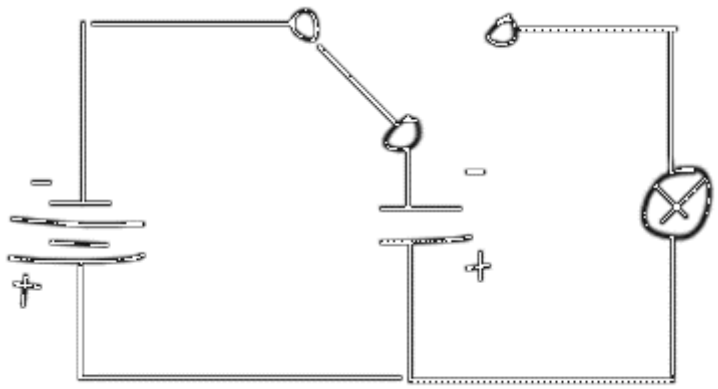
---

401. Give a pro and con of low-orbit satellites

+Closer ∴ cheaper and less powerful transmitters need.
-High speeds ∴ constant coverage required.

---

402. Give a use of a capacitor



Basically, used to store energy for powering bulbs, starting motors, etc. *You can also have a variable capacitor in which you can change the surface area of of overlap to increase capacitance.*

---

403. How does the electric field strength vary in a uniform field and what is its equation?

It is constant throughout the field.

$$E = \frac{V}{d}$$

Where V is the potential difference between the plates and d is their separation.

---

404. What is Faraday's Law?

Emf induced in a circuit equals rate of change of magnetic flux linkage.

Lenz's law

$$\boxed{\varepsilon = -N\frac{\Delta\Phi}{\Delta t}}$$

---

405. What uses are there of alpha particles?

Smoke detectors.
They're not used in the body because of how ionising they are. They're only dangerous if they get into your body. Gamma rays are more dangerous as they can penetrate your body.

---

406. How should you handle radioactive sources safely?

1.Use long tweezers (around 30 cm).
2.Return to container when finished to limit exposure time.
3.Point away from body holding at arms length.

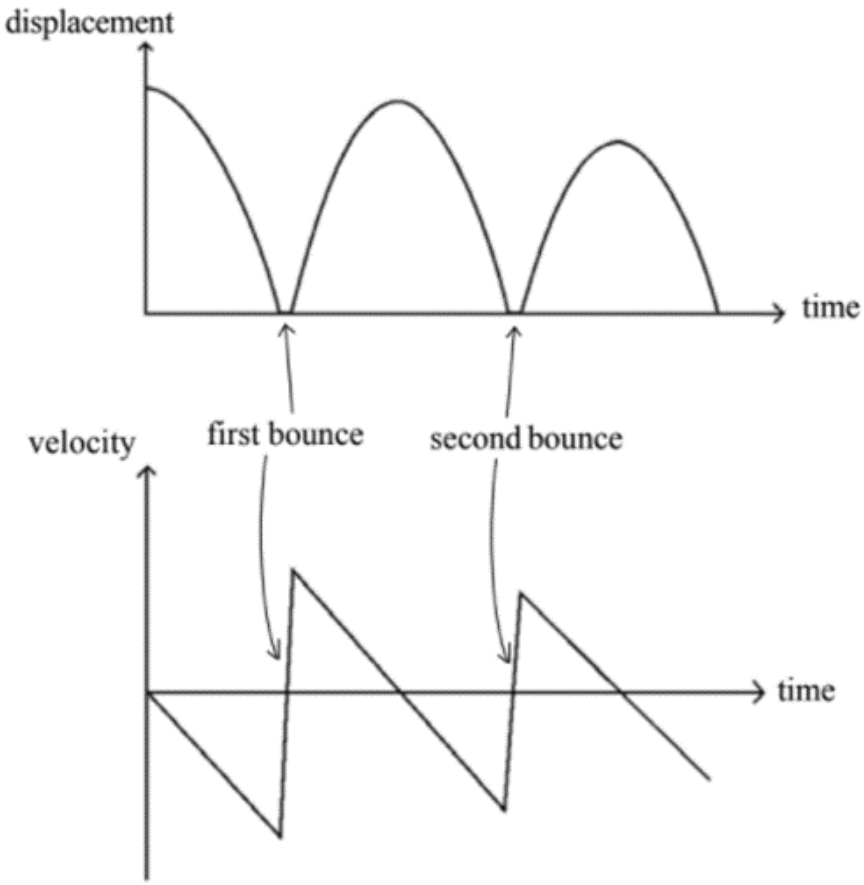
---

407. How should you deal with anomalies during a radioactivity experiment?

Don't ignore them, use them when calculating means.
Since radioactive decay is a random process., you cannot predict when an individual nucleus will decay. Yet with a large number of nuclei, you can use a statistical approach.

---

408. Sketch the velocity and displacement time graph of a bouncing ball (taking the ground being the origin and up as posititve)



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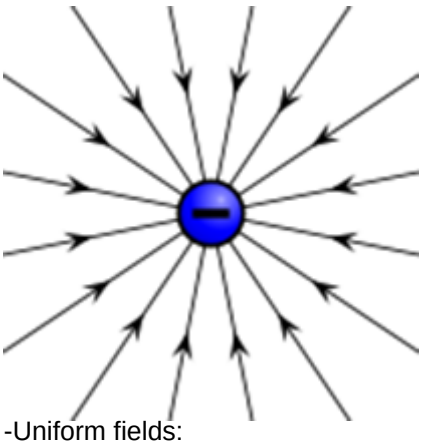
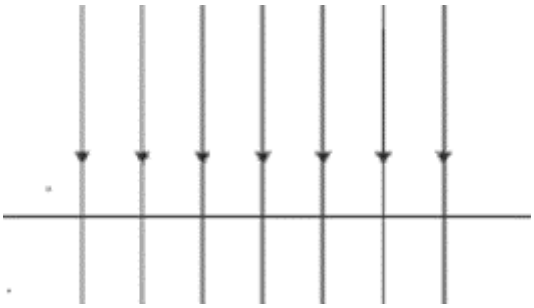
409. What are the 2 types of fields?

-Radial fields:



-Uniform fields:



This is approximately what it looks like at the Earth's surface.

---

410. What the equation for Newton's Law of Gravitionation?

The attractive force between 2 point masses is proportional to the product of their masses and inversely proportional to the **square** of the distance between them.

$$F = \frac{Gm_1m_2}{r^2}$$

F is the force between the two objects (N), G is the gravitational constant, m_1 and m_2 are the masses of the two objects and r is the distance between the centre of masses (m).

---

411. How can the formula for escape velocity be derived?

Set the kinetic energy equal to the gravitational potential energy and solve for v.

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

$$\frac{1}{2}v^2 \geq \frac{GM}{r}$$

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

$$v \geq \sqrt{2gr}$$

Use $g=GM/r^2$ to get from the 3rd to 4th line.

---

412. What is the energy of a satellite and how does it work in an elliptical orbit?

- The sum of the GPE and KE (which stays constant overall).
- Closer to the orbited mass, it speeds up as GPE turns into KE.

---

413. How can Kepler's Third Law be derived?

By equating the centripetal force and gravitational force and approximating the orbit as a circle.

$$F_c = F_G$$

$$m_{sat}\frac{v^2}{r} = G\frac{m_{sat}M}{r^2}$$

$$v^2 = G\frac{M}{r}$$

$$\left(\frac{2\pi r}{T}\right)^2 = G\frac{M}{r}$$

$$\frac{4\pi^2 r^2}{T^2} = G\frac{M}{r}$$

$$\frac{r3}{T^2} = G\frac{M}{4\pi^2}$$

This is only depends on the mass (the proportionality constant differs for the Sun and Earth).

---

414. What is capacitance defined as?

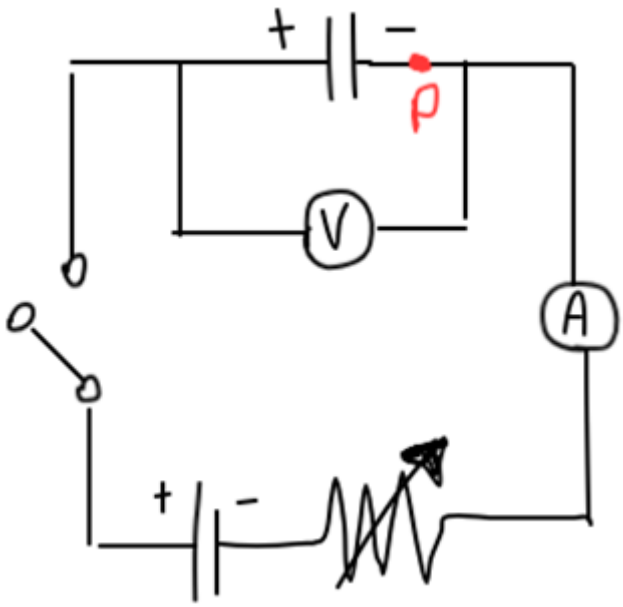
The charge stored per unit voltage of pd across the capacitor measured in Farads (F).

$$Q = VC$$

The capacitance of a capacitor **CANNOT** change.

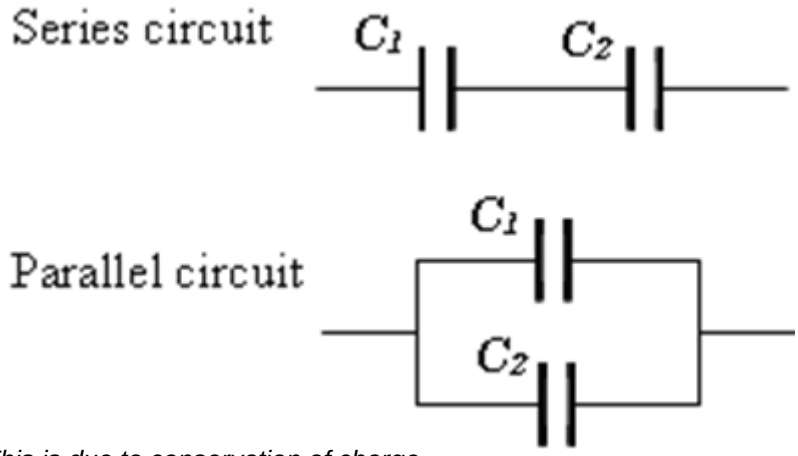
---

415. How can you maintain a constant current in a circuit with a capacitor?



-With a variable resistor, you can have a high resistance at the start ∴ low current. Yet when the current begins to decrease, you can reduce the resistance.
-Without a variable resistor, the current would decrease over time as when enough negative charge builds up at P, it will repel any more incoming.

416. Derive the equation for capacitors in parallel and in series



This is due to conservation of charge.

For parallel:

$$Q = VC$$

$$Q_T = Q_1 + Q_2$$

$$VC_T = VC_1 + VC_2$$

$$C_T = C_1 + C_2$$

For series:

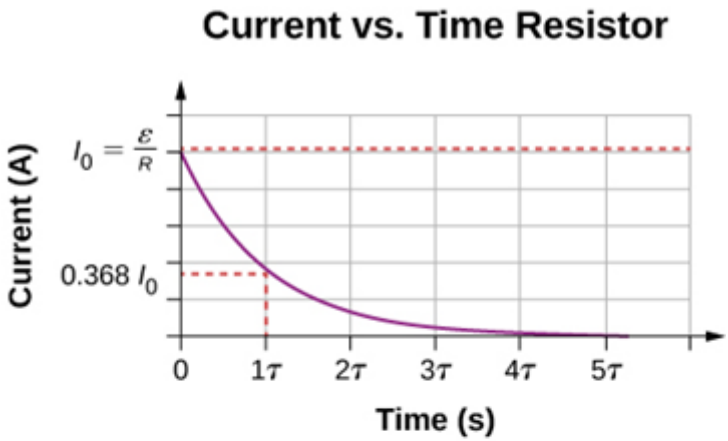
$$V_T = V_1 + V_2$$

$$\frac{Q}{C_T} = \frac{Q}{C_1} + \frac{Q}{C_2}$$

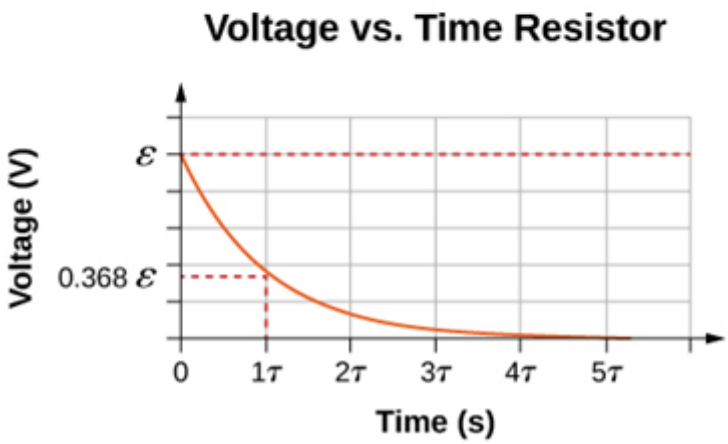
$$\frac{1}{C_T} = \frac{1}{C_1} + \frac{1}{C_2}$$

417. What is the discharging graph of a capacitor from the equation?

$$Q = Q_0 e^{-\frac{t}{RC}}$$



(b)



(d)

It's considered fully discharged after 5 time constants.

---

418. What is Coulomb's Law?

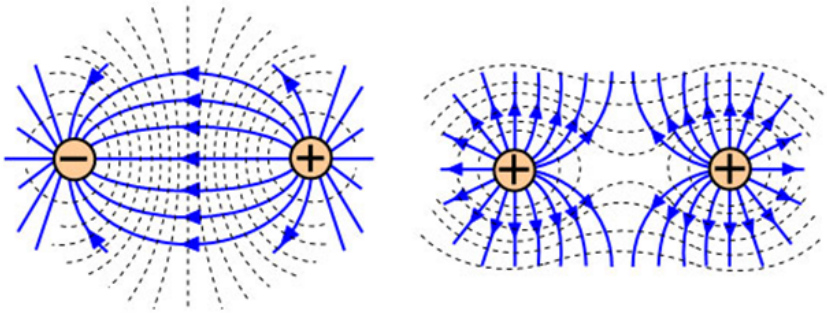
Force between two point charges (where attractive is negative and repulsive is positive).

$$F = \frac{1}{4\pi\varepsilon_0}\frac{Q_1 Q_2}{r^2}$$

Air can be treated as a vacuum thus use ε_0.

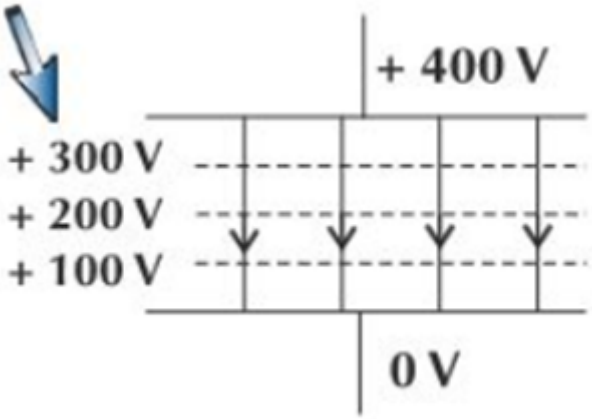
---

419. What does an electric field look like between two-like charges and between two-opposite charges?



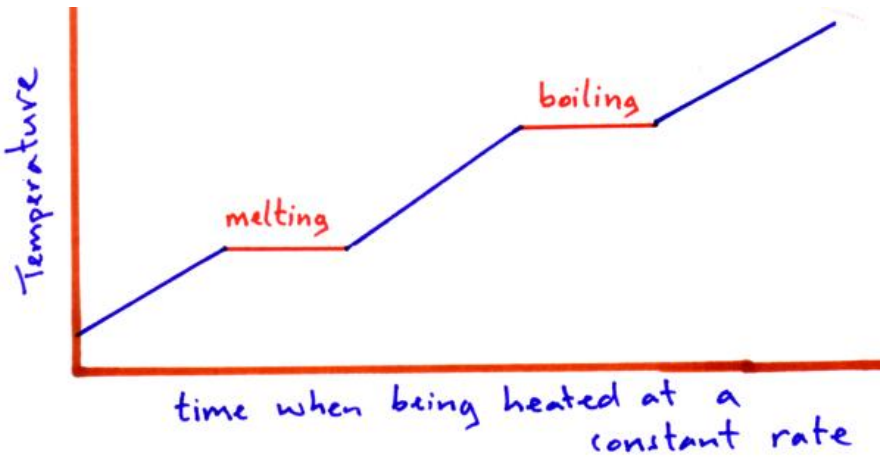
420. How are the equipotentials different in a uniform field?

They're parallel and evenly spaced.



The electric field strength is constant throughout, the distance decreases so must the potential difference.

421. What are the 2 types of latent heat?



- Solid to liquid - latent heat of fusion.
- Liquid to gas - latent heat of vaporisation.

Interestingly enough, sublimation is going straight from solid to gas which is how you can smell soap.

422. What did Brownian Motion show the existence of?

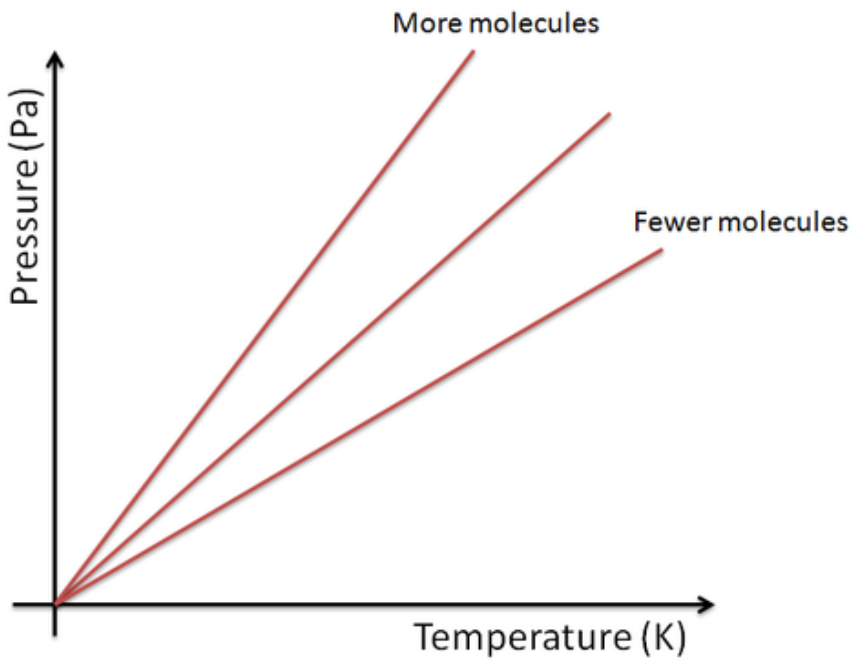
Molecules and atoms which more randomly.

423. Define isobaric

Constant pressure (as **ba** for **ba**rometers).

424. What is the Pressure Law? (with a graph and justification)

- Pressure ∝ Temperature for constant volume.



*Since P = Nk/v * T, steeper gradient means more molecules.*

- If you fix the volume and increase the temperature, the particles have more kinetic energy and thus move faster, have more frequent collisions with the walls thus experiencing greater change in momentum / second on same area thus increasing pressure.

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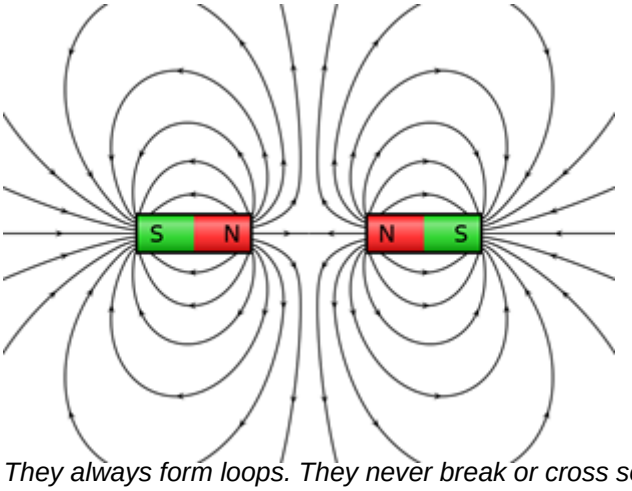
425. What is a magnetic field?

●A region surrounding a magnetic / current carrying wire which shows the direction a tiny north pole would move (hence go north to south).



They always form loops. They never break or cross so go through the magnetic itself.

This always means that geographic north pole is actually the magnetic south pole and vice versa.

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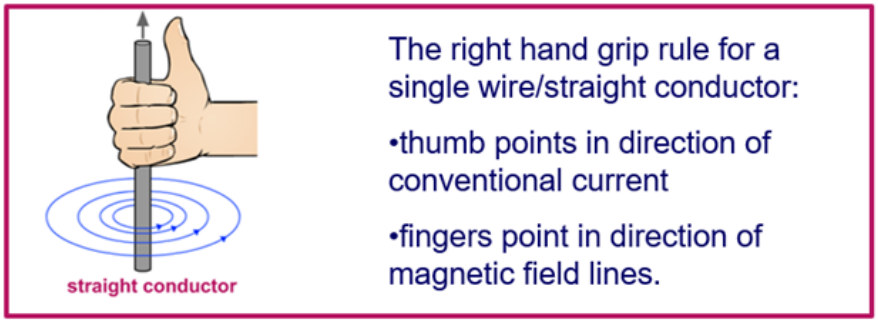
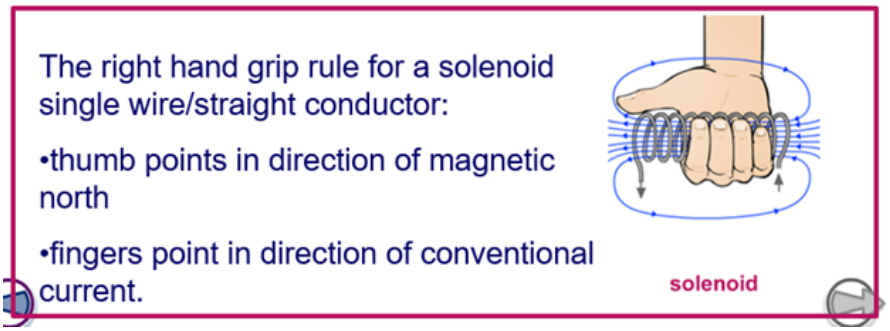
426. What is the right-hand grip rule and in what 2 cases is it used?

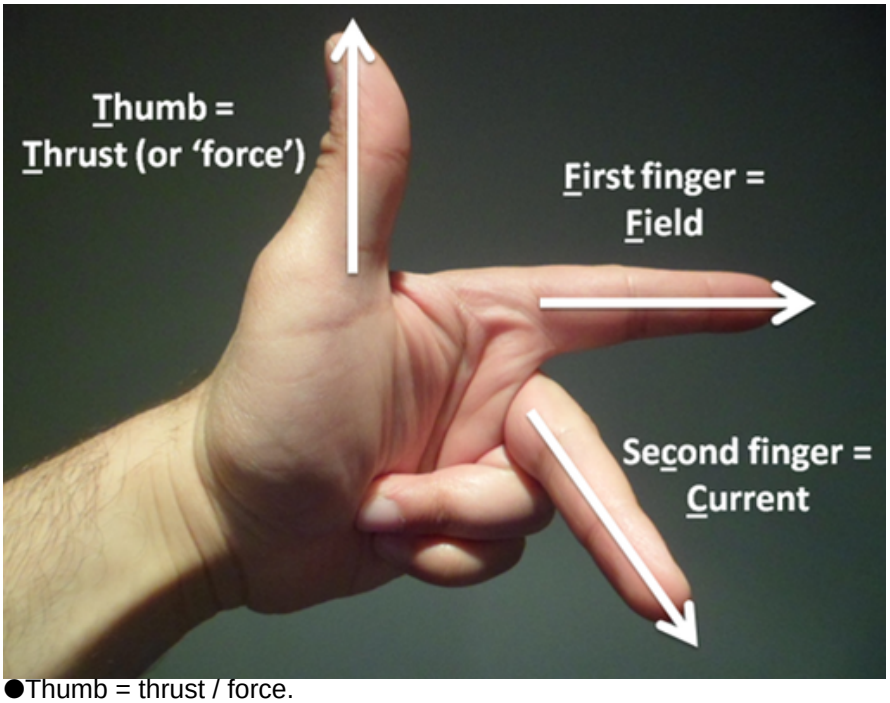
Current-carrying conductor:



Solenoid:

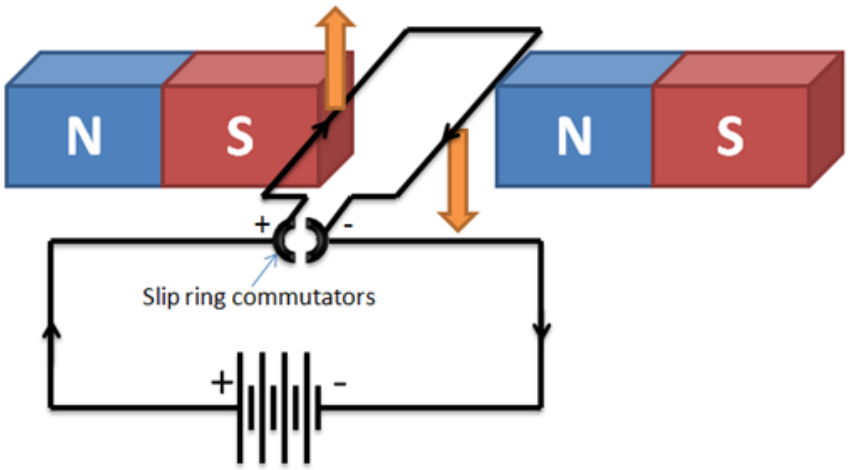


427. What is Fleming's Left Hand rule? What is it used for?



●Thumb = thrust / force.
●First finger = field (going north to south).
●Second finger = conventional current.
●Used to determine the direction of the force in the motor effect (where current and field are known).
Motor cars drive on left so we remember it as Fleming's left hand rule for motor effect

428. How is the motor effect used in an electric motor?



Current enters loops around leading to an upwards force on side and downwards on the other side.

---

429. How are magnetic fields represented in 3D?

- Using darts.
- Dot (·) - dart coming towards, out of page.
- Cross (X) - dart moving away, into page.

---

430. When is the force on a moving charge equation below valid?

$$F = BQv$$

When the particle is travelling perpendicular to the direction of the magnetic field.

---

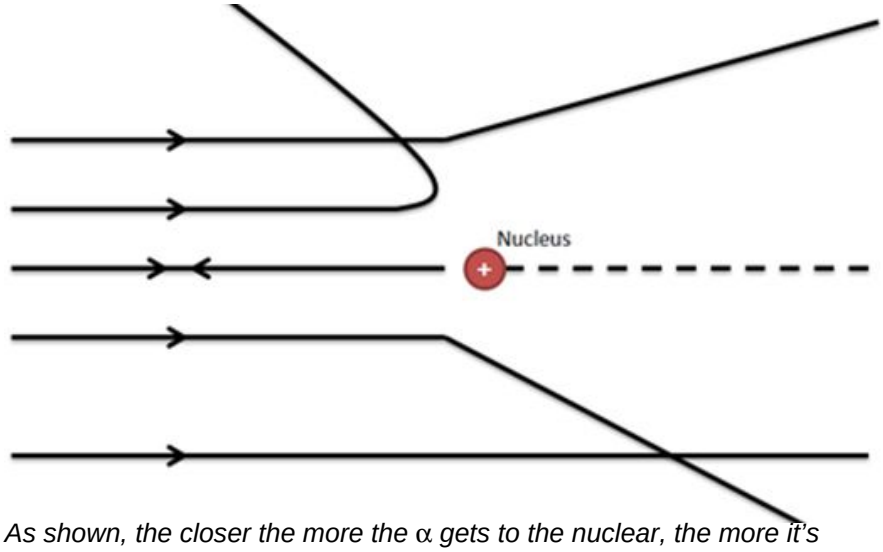
431. Why do electrons from pair production sometimes move apart?

As it happens in a magnetic field which is stronger than the electric field between them.

---

432. What are the results of the Rutherford Gold Foil Experiment? What do these mean?

●Most α particles went **straight through** - most of atom is empty space.
●Some α particles **deflected marginally** and even fewer **bounced back** - very small dense positive charge (most mass concentrated here).
■This backscattering couldn't be explained by the plum pudding model.



As shown, the closer the more the α gets to the nuclear, the more it's deflected. Even very fast alpha particles are deflected so it must be very dense.

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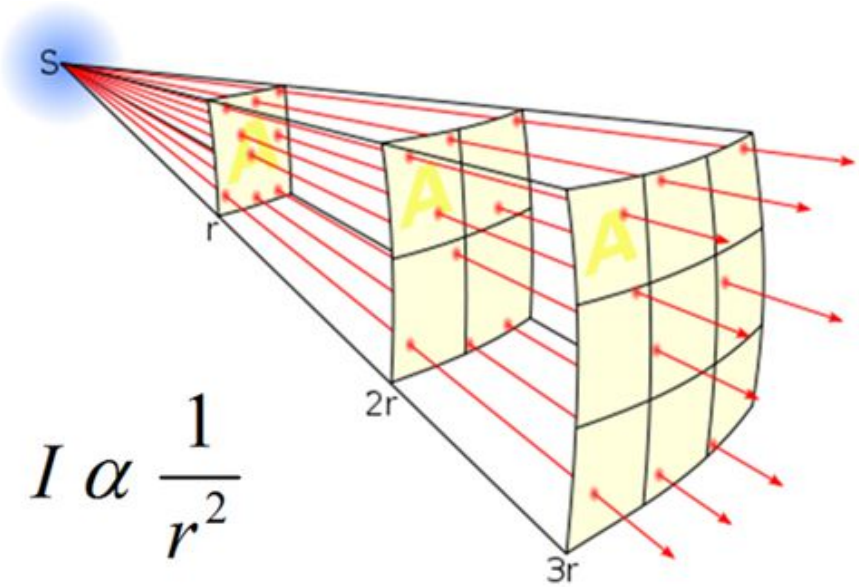
433. How law does γ radiation follow?

The intensity of radiation follows the inverse square law.



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434. What should be measured before carrying out an experiment using radioactivity?

Measure background radiation count over a course of several minutes. Then work out the count rate.

---

435. Why does the count rate for β^- decay decrease further from the source?

As different β^- decay particles start out with different amounts of kinetic energies

---

436. What should you do to micrometers and vernier callipers before use? What does this ensure?

- Tare/zero them.
- There is no systematic error.

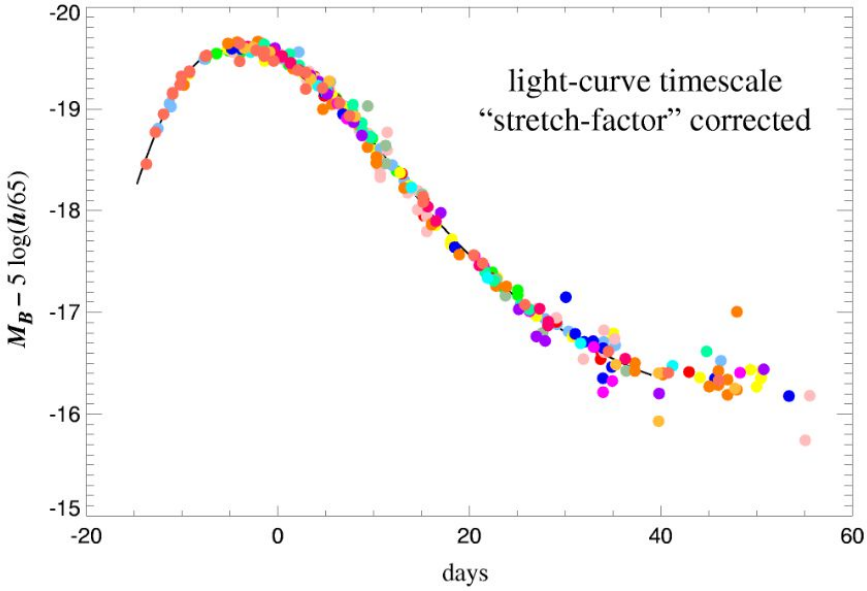
---

437. When does a supernova occur? What is left behind and why?

- When the remaining core mass ≥ $1.4m_{sun}$ fuses upto iron and it's no longer energetically favourable to fuse any heavier elements.
- Leaving behind a neutron star or black hole.

---

438. Draw the light curve for a type 1a supernova



Peaks at around M = -19 with scale going in 10's of days.

---

439. What are exoplanets and why are they hard to detect?

- Planets that don't orbit our Sun.
- Because they don't emit their own light.

---

440. What is Gravitational Field Strength and what are the equations for it?

-It is the amount of force something would feel per unit mass (Nkg^{-1}).

$$g = \frac{F}{m}$$

g is the gravitational field strength (Nkg^{-1}), F is the force due to gravity (N), m is the mass of the object (kg).

This can be rewritten for radial fields:

$$g = \frac{GM}{r^2}$$

g is the gravitational field strength (Nkg^{-1}), G is the gravitational constant, M is the mass of the object (like the Earth rather than the person, although you can do it vice versa) as gravitational field strength is independent of the mass, r is the distance from the centre of mass.

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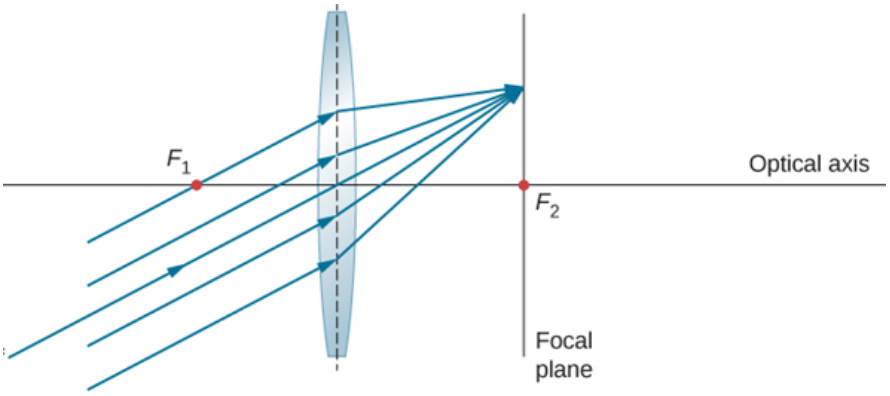
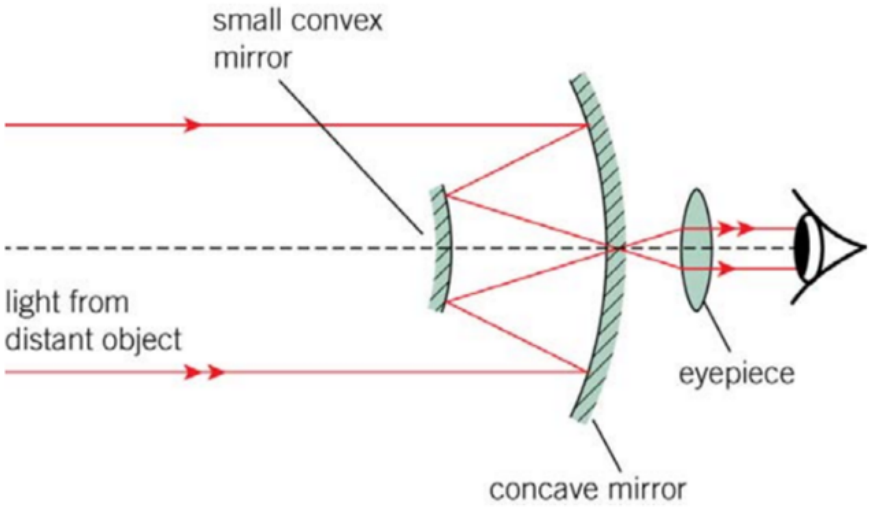
441. What is the ray diagram of object lying on focal plane with a converging lens?



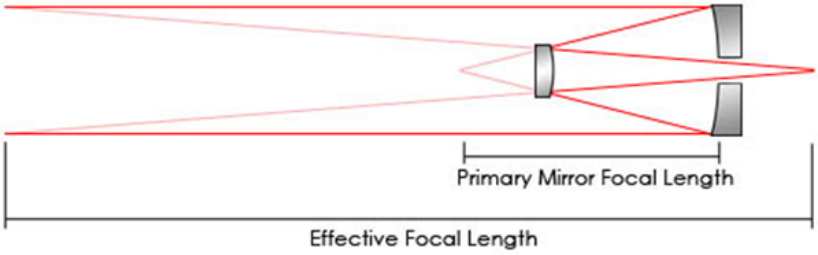
It appears to from at infinity.

---

442. Draw a Cassegrain reflecting telescope



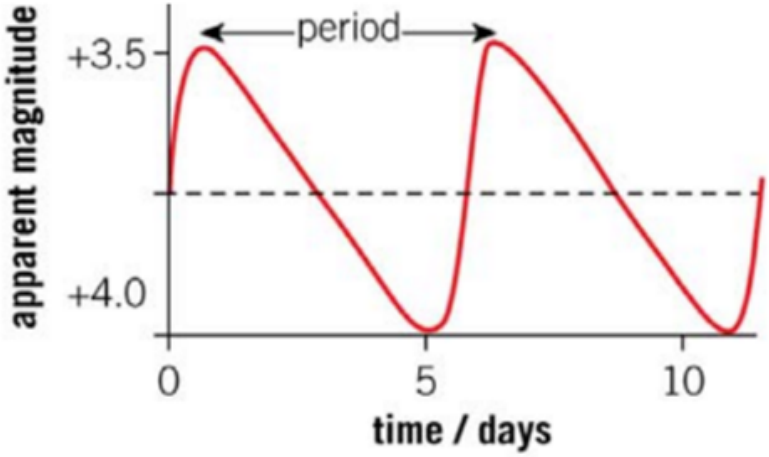
-The effective focal length is…



443. What is the cosmological principle?	The universe is homogeneous (same composition throughout) and isotropic (looks the same in all directions).
444. What is radial velocity?	The velocity of an astronomical body along the line of sight of the observer.
445. How are main sequence stars in equilibrium?	The inward gravitational attraction = outward radiation pressure.
446. What is a supernova?	An astronomical object that has a rapid increase in brightness.
447. What is a Type 1a supernova and how are they used? What are they known as?	- Supernovae that reach a known **PEAK** luminosity used to find the distance to the host galaxy. - This is by using the known absolute magnitude and the observed apparent magnitude in the equation. - They are called standard candles.
448. How would you infer the uncertainty from data?	Look at the lowest number of significant figures (e.g., a reading of e.g., 2.3 x 10^3 will have an uncertainty of ±0.05 x 10^3).
449. What is focal length defined as?	The shortest distance from the lens axis to the focal plane.

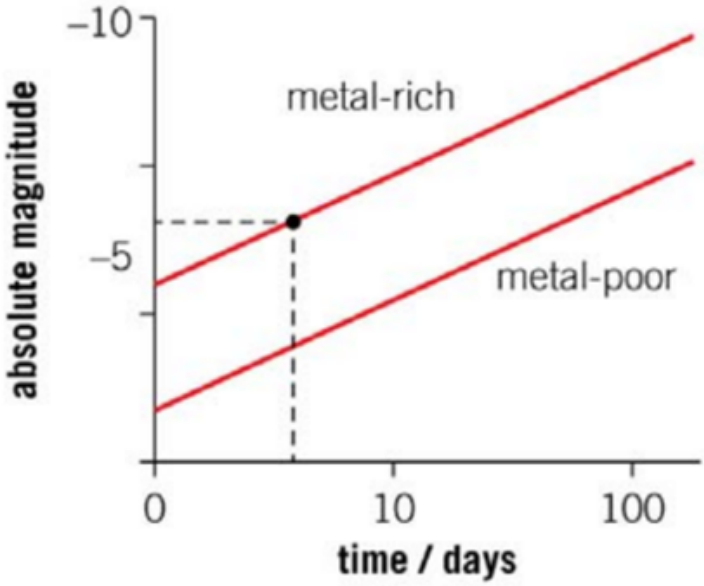
450. What is a cepheid variable and how can the distance to it be calculated?

- A star whose luminosity varies.



(a) variation of apparent magnitude with time for a typical cepheid variable

- It can be calculated by measuring the period which gives the absolute magnitude then using the apparent-absolute magnitude formula.



(b) absolute magnitude v period relationship

---

451. What is a black hole?

An object with an escape velocity greater than the speed of light.

---

452. Describe the light rays from distant objects

Light rays from distant objects are effectively parallel when they reach the telescope.

---

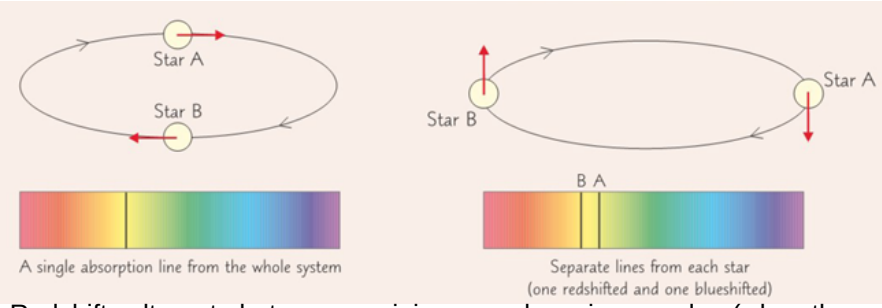
453. What is the formula for the Doppler Effect and when can it be applied to EM waves?

$$z = \frac{v}{c} = \frac{\Delta f}{f} = -\frac{\Delta \lambda}{\lambda}$$

Can only be applied to EM waves when v << c.

---

454. How does redshift affect binary stars? (with diagram)



-Redshifts alternate between a minimum and maximum value (when the star is moving towards / away from Earth).
-They meet halfway when they're moving perpendicular to our line of sight.
It's halfway when the stars are the same mass. Otherwise, they'll move with different speeds and orbital radii (due to a barycentre) so greater $\Delta\lambda$ for the faster, less massive, star.

---

455. What is precision and accuracy?

- Precision is the smallest resolution.
- Accuracy is how close you are to the true value.

---

456. What are the 3 cases for objects lying along the principal axis?

1.Between the principal focus and lens.
2.On the focal plane.
3.Between the principal focus and infinity.

---

457. What is the angular magnification of a telescope and when can it be used?

$$M = \frac{\text{angle subtended by final image}}{\text{angle subtended by distant object}}$$

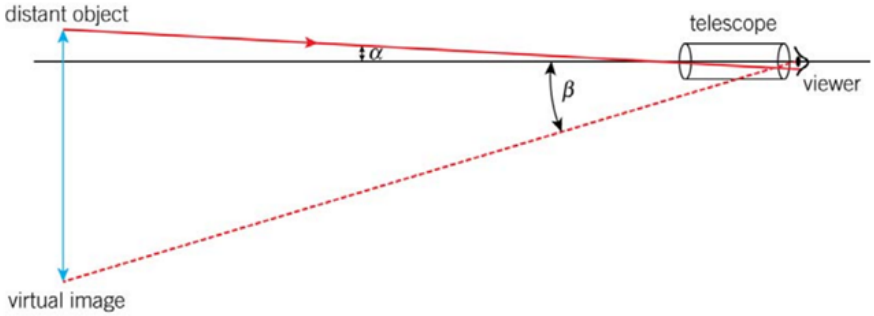
OR

$$M = \frac{f_o}{f_e}$$

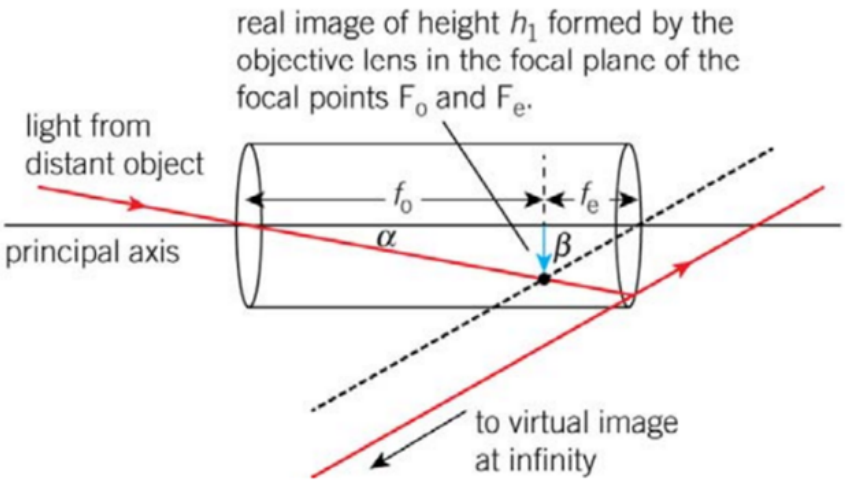
Where f_o is the focal point of the objective and f_e is the focal point of the eyepiece.

Used for a telescope in normal adjustment.

DERIVED FROM



You can derive the second relationship by using the diagram below. Note: small angle is applied here since the angles ≤ 10°.



458. Why are steerable telescopes used?

To compensate for the Earth's rotation.

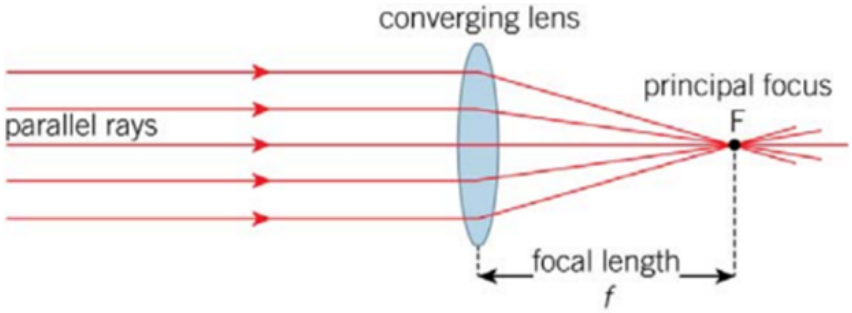
459. How was the Milky Way mapped? Why does this work?

- Using radio waves.
- Since e^-'s in ^1H in gas and dust clouds flipped their spin.

460.	Which telescopes have to be in space and why?	-UV, X-Ray and Gamma Ray telescopes -Since... UV is absorbed by the ozone layer, X-Rays & Gamma Rays are absorbed,
461.	Define absolute magnitude and apparent magnitude	-Absolute magnitude - the brightness of a star as seen 10 pc away from Earth. -Apparent magnitude - the brightness of a star seen from Earth (a measurement of the amount of light reaching Earth) *This is brightness in the visible region, a star may be emitting light more brightly in other regions.*
462.	What are the prefixes ≥ 1000?	- Kilo (K) - 10^3 - Mega (M) - 10^6 - Giga (G) - 10^9 - Tera (T) - 10^{12}
463.	What are the prefixes ≤ 0.001?	- Milli (m) - 10^{-3} - Micro (μ) - 10^{-6} - Nano (n) - 10^{-9} - Pico (p) - 10^{-12} - Femto (f) - 10^{-15}
464.	What should be done if there is a zero-error?	Calibrate the device.
465.	How do you find the percentage uncertainty from a graph?	1. Draw a line of best fit and line of worst fit going through the error bars. 2. Choose the furthest gradient (yet, in most cases, they may appear symmetrical) and the difference between the best and worst is the uncertainty divided by the line of best fit will be it. E.g., if the m_{best} = 20 and m_{worst} = 18 then % uncertainty is (20 - 18) / 20 = 10%.
466.	What should you do when adding or subtracting values with uncertainites?	Add the **ABSOLUTE UNCERTAINTIES**.
467.	What should you do when multiplying or dividing with uncertainties?	Add the **PERCENTAGE UNCERTAINTIES**.
468.	What should you do when you have an uncertainity to a power?	Multiply the **PERCENTAGE UNCERTAINTY** by the power.
469.	Describe what orders of magnitude are about with an example	- Making estimates to check answers. - E.g., an apple of 1N (0.1kg) would have an order of magnitude of 10^{-2} kg.

470. What is the principal focus / focal point and ray diagram for a converging lens?

The point where rays parallel to the principal axis are focused to.



471. Define both real and virtual images

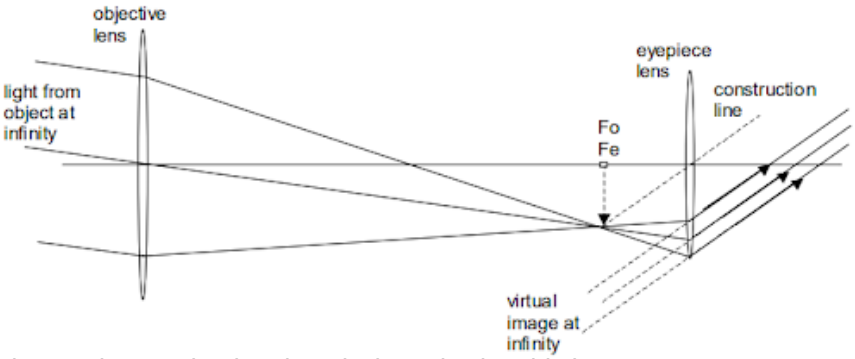
-Real - when rays actually go to that point.
-Virtual - when rays don't go to that point yet appear to come from it.

472. How does distance of an object to lens affect where a clear image forms?

The closer it is to the principal focus (yet > the focal length) the further a clear image is formed by the lens.
This is because the lens can only bend the light so much, otherwise, you need a stronger lens.

473. When is a telescope in normal adjustment and how does this affect the image?

- When the distance between the lenses is the sum of their focal lengths (i.e., focal points coincide).
-Image forms at infinity since the image from objective lens forms on the focal plane of the eyepiece lens.



The eye is completely relaxed when viewing this image

474. How does the collecting power of a lens relate to its size?

$$\text{Collecting Power} \propto \text{Area} \propto \text{Radius}^2$$

475. How does brightness vary when viewing different astronomical objects?

-When viewing stars, they appear as brighter points objects ■ the telescope collects more light.
-Planets and other bodies appear no brighter ■ not point objects ∴ when more light is collected, it's spread over a larger area.

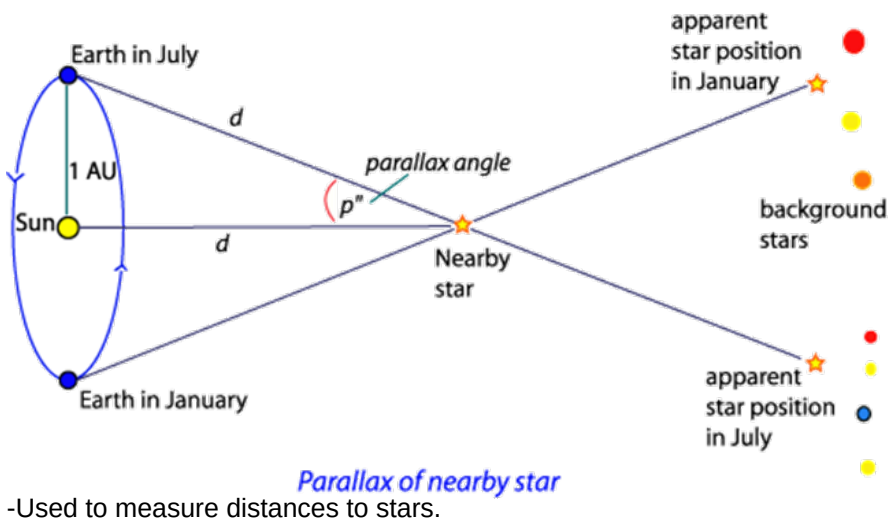
476. How do radio and optical telescopes compare?

+ Radio have less precision in their design since larger wavelength.
-Radio have to be bigger or linked up to match optical telescopes.

477. Define quantum efficiency

The percentage of photons turned into electrons.

478. Describe the parallax method



-Used to measure distances to stars.
-Parallax angle is half the angular shift.

---

479. What is Stefan's Law?

-$L = \sigma A T^4$
-Where L is luminosity (synonymous with power), σ is the Stefan-Boltzmann constant, A is surface area, T is temperature.

---

480. When does a star become a red giant?

When it runs out of hydrogen fuel to burn.

---

481. What is the Schwarzschild radius?

The radius of the event horizon (where escape velocity = c).

---

482. How can Hubble's Law be used to estimate the age of the universe?

Altering the units of H and working out T = 1/H.

---

483. What are random and systematic errors?

- Random errors - statistical fluctuations in data due to experimeter's ability (eliminated by repeating).
- Systematic errors - inaccuracies present through the whole experiment.
Move this to chemistry afterwards.

---

484. What were quasars discovered as?

STRONG SOURCES OF RADIO WAVES.

---

485. Where do visible telescopes have to be placed and why?

Far from civilization and hence light pollution.

---

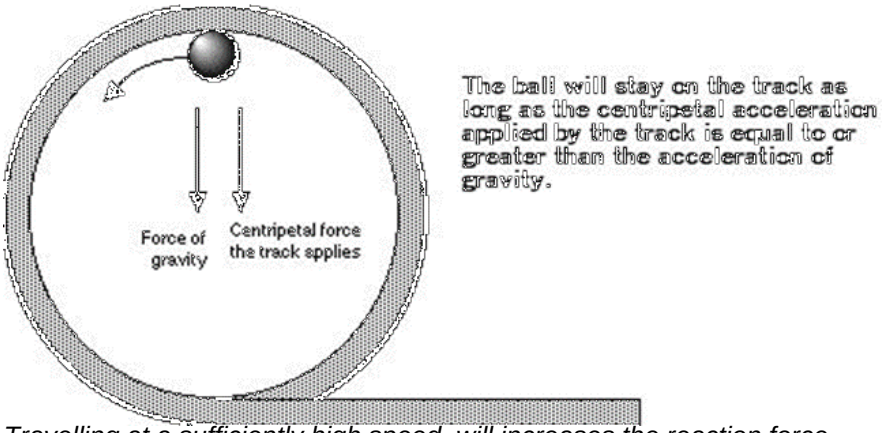
486. When and why does a star swell up into a red gaint?

Hydrogen exhausts itself (1) so the core collapses leading to temp. increase (1) causing outer parts expand (1) leading to decrease in temp. (1) so red (1)

---

487. How can a roller coaster go upside without falling off?

- It's moving fast enough (1) such that the **centripetal force is greater than or equal to its weight** (so $F_N = F_{CP} - mg$) (1) as the starting height provides a great enough GPE to provide sufficient KE (1).



Travelling at a sufficiently high speed, will increases the reaction force applied from the track.

---

488. Describe progressive waves

- Waves that transfer energy from one point to another (1) without transferring material (1).
- The amplitude is the same for all particles.

---

489. What is a hadron?

A particle that **IS** subject to strong interaction.

---

490. What fact is the potential divider based on and why? And what does this mean?

- **P.d.** ∝ **resistance** under constant current ■ electrons **need more energy** to overcome the resistance.
- Meaning the resistor with **greater resistance** will have a **greater share of the p.d.**