# Topic 5 – Further mechanics

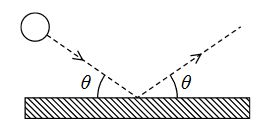
## Further momentum

Elastic collision: KE conserved

Inelastic collision: KE not conserved

Impulse is the change in momentum:

So average force during collision:

Bounce collision

* Force acts opposite direction to initial movement

Solving collision momentum problems

* Draw a vector diagram and use Pythagoras theorem to solve the problems
* Use trigonometry to find angles
* Draw scaled vector diagram to check your answers

Why can a scaled vector diagram demonstrate conservation of momentum?

* Sum of momentum before and after collision is the same
* As the mass is the same, sum of velocity before and after collision is the same

## Circular motion

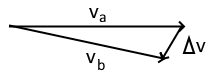
Angular velocity:

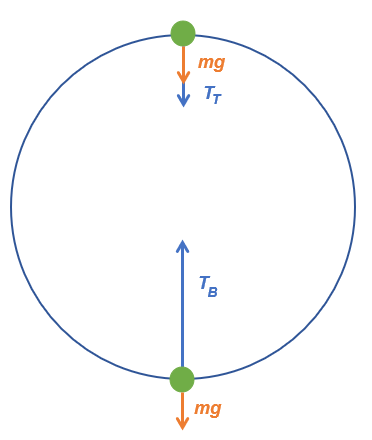
Instantaneous velocity:

Centripetal force acts 90 degrees to the direction of motion

Why does an object move with circular motion

* Resultant force by other forces which acts perpendicularly to the direction of motion

Derive

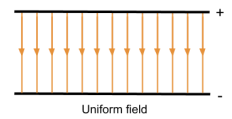
1. Draw vector diagram (RHS)

### Vertical circular motion

# Topic 6 - Electric and magnetic fields

## Electric fields

Electric field - force field in which charged particles experience a force



To draw field lines:

1. Current +ve → -ve terminal

2. Straight parallel lines

3. Evenly spaced lines

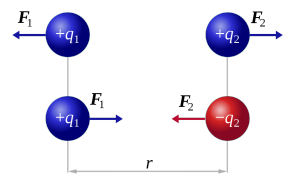
### Uniform fields

### Radial fields

To explain the direction of the electric field at a point:

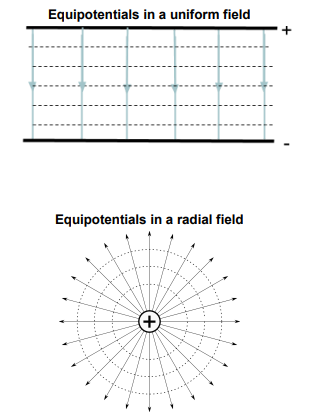
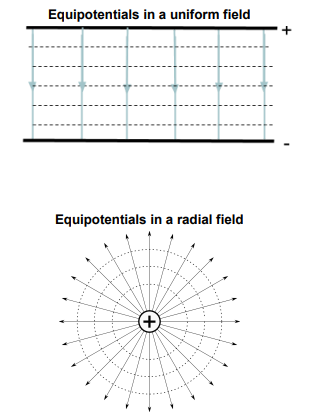
1. Due to A being +ve, e-field is exerted away from A:
2. Due to B being -ve, e-field is exerted towards B:
3. (as vertical component cancelled out)

### Coulomb’s law

If charges have the same sign, F ≥ 0 and hence the force will be repulsive, else it will be attractive

### Equipotentials

Join points with equal potential in an electric field together to create surfaces of equipotentials



### Thermionic emission

e- in heated metal gain energy and leave surface

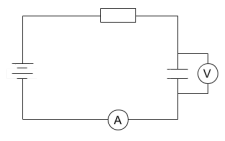
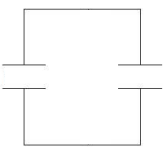
**Electron guns**

1. hot metal surface causes emission of e-
2. anode +ve charge accelerates e-

### Earth’s magnetic field

Distance from poles ↓ Magnetic field strength ↑

## Capacitors

* Stores energy
* Total charge = 0
* Separates charge

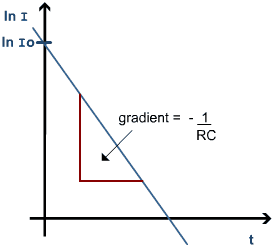
To explain charging capacitor with e- flow

* e- move from one plate to another through external circuit
* As capacitors charge, rate of flow of e- ↓
* When fully charged, equal amounts of e- stored on each plate

### Charging and discharging properties

|  |  |
| --- | --- |
| Charging | Discharging |
|  |  |

To find the time constant with \*-t graph:

1. Locate the initial value for Q | V | I
2. Calculate value at 37% if charging, 63% if discharging
3. Use the graph to find corresponding time

To find time constant with straight-line graph

1. Natural log both sides →
2. Re-arrange variables to make

### Energy

Energy charged / discharged by capacitor is the energy dissipated / gained by other components.

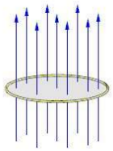
## How Magnets WorkMagnetic fields

Magnetic poles always exist with both North and South poles, N → S, S → N if at the center

### Magnetic flux

Uniform magnetic fields - constant magnetic flux density

Magnetic flux density (B, Unit Testa (T)) is a measure of the strength of the field

Magnetic flux (, Unit Weber (Wb)) describes magnetic field lines cutting through a given area:

When , there are no field lines cutting through A

Magnetic flux linkage:

### Directions of vectors

⨀: Out of paper F: Magnetic force

⊗︀: Into paper iL: Induced current

|  |  |  |
| --- | --- | --- |
| Force direction: LHR | Induced current direction: RHR | Magnetic field direction: Grip rule |
|  | Electromagnetism Resource | Right-hand rule - Wikipedia |

To explain directions of vectors:

* State “Using LHR”, or state

To think of questions with magnet on a weigh:

* Note that the reason for the increasing reading is due to the reaction force experienced by magnet when it exerts an **upward** force onto the conducting material, which by 3rd law, it exerts a **downwards reaction** force onto the magnet
* Directions of forces should reference LHR

### Charged particles in magnetic fields

A force acts on charged particles moving in a magnetic field

­Magnetic Force on wires:

Magnetic Force on particles:

As force acts to motion of charged particles (LHR), particle motion is circular:

Radius of circular path of particles:

Use to find variables of particle in magnetic field.

For a negative charge, the current will be flowing in the opposite direction relative to its movement

### Electromagnetic induction

Lines of magnetic field cut through coil → emf is induced.

Coil forms a complete circuit → Current is induced.

Lenz’s law: Direction of induced current is such as to oppose the motion causing it

Lenz’s law can be applied to explain direction of movement. Also can think of as “minimizing” motion causing it

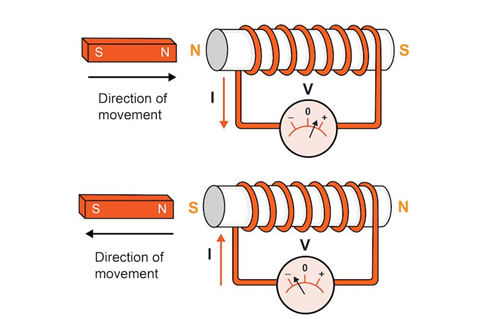
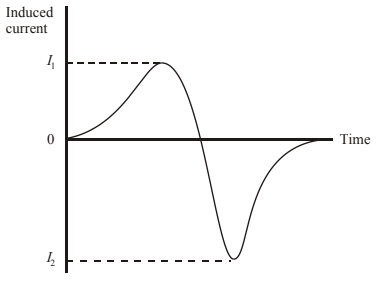
Faraday’s law: definition

Average induced emf: (maximum amplitude of V)

## Applications of magnetic fields

### Demonstrating Lenz’s law induction

1. Due to Lenz’s law, **direction of induced is such as to oppose the motion** of the magnet  
   **Same pole** is induced to the pole of the magnet **approaching** coil, causing magnet to slow down due to **repulsion** force
2. Due to Lenz’s law, **direction of induced is such as to oppose the motion** of the magnet  
   **Opposite pole** is induced to the pole of the magnet **leaving** coil, causing magnet to slow down due to **attraction** force

“Induced current flows in a direction such that it opposes the change which produces it”

Note that the magnitude of the second peak is greater ∵magnet at higher velocity ∴rate of change of flux greater

Work done due to Lenz’s law:

* , therefore the movement caused by Lenz’s law does work

### How does a transformer increase the pd?

1. AC provides alternating current
2. AC produces varying magnetic field in core (T)
3. Diode converts AC to DC

### Generators & motors

|  |  |
| --- | --- |
| **AC Generator** | **DC Motor** |
| * The coil is rotated mechanically * F and B 🡪 induces emf & current onto coil (RHR) * Current alternates (AC) as coil cuts max and no field lines when rotating, inducing max and 0 emf | Draw a labelled diagram of an electric motor. Explain its principle and  working. What is the function of a split ring in an electric motor?   * Current is supplied to the system * I and B 🡪 exerts magnetic force onto coil (LHR) * Coil rotates by resultant force |
| Animation: [Click me](https://www.youtube.com/watch?v=gOB4OmwK7yc) | Animation: [Click me](https://www.youtube.com/watch?v=0q5bARctt7M) |

# Topic 7 – Particle physics

## What is Atomic Structure? | Definition from Seneca LearningAtomic model

### Nuclear model of an atom

*Evidenced by α-scattering Disproving plum-pudding model*

1. Most α no deflection 🡪 Atom is mostly empty ✖ As pp model atom matter spread out
2. Small amounts α deflected 🡪 Center is charged (+ / -) ✔ pp model doesn’t have high conc. charge
3. Very small amounts α deflected > 90° 🡪 Center is very dense ✔ pp model doesn’t have high conc. mass

Deduce the closest distance of α to center of nucleus

* Idea: pd in nucleus = pd in particle, then the particle will be closest to nucleus

### Charge of particles

All particles have a charge relative to e (1.6x10-19)

## Particle accelerators

### Accelerating potential

Accelerating pd is used to accelerate particles.

Find momentum of particle / number of passes in LINACs

* Remember if a particle passes through tubes, the energy gained by particle is only

### Types of accelerators

|  |  |
| --- | --- |
| **Linear accelerators**: Alternating electric fields  Why gaps & tube must increase in length further down LINAC   1. Electric field accelerate particle across gap 2. Particle speed constant in tube 3. pd oscillate at constant intervals, so time for particle staying in gaps & tubes is constant 4. Particle enters gap & tube with increasing speeds, s=vt, so gaps & tubes must increase in length | **Cyclotron**: Electric + Magnetic fields  Why only t is needed to time acceleration of particles   1. Speed of particle has no relationship to the time 2. Since time for particles staying in dees is constant 3. So pd oscillate at constant intervals 4. As pd across gap is in correct direction to accelerate particles each time they pass |

Why high energy particles required to investigate structure of nucleons

* Wavelength needs to be comparable to nucleon size

## Mass and energy

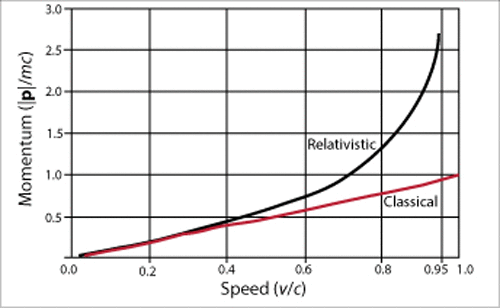
### Generation and destruction of mass

* E, Q & p are all conserved
* Pair production can only occur near a nucleus as the nucleus can allow conservation of energy by receiving recoil

|  |  |
| --- | --- |
| Pair production | Pair annihilation |

### Time dilation & relativistic lifetime

Time dilation - Time travels slower for faster moving objects.

1. Initial distance speed
2. At speeds approaching c, lifetime observed stationarily > predicted lifetime due to relativistic increase
3. Particle travels further as lifetime extended

## Standard model of elementary particles

Hadrons - Formed of quarks

Leptons - Fundemental particles

Quarks - Makes up leptons. Fundemental particles

Fundemental - Cannot be broken down further

### Quarks & leptons

You’ll need to memorize particle charges for exams:

Antiparticle: Equal mass, equal and opposite charge & baryon / lepton number

|  |  |  |  |
| --- | --- | --- | --- |
| Quark | | | Charge |
| 1st | 2st | 3rd | Gen |
| u | c | t |  |
| d | s | b |  |
| Leptons | | |  |
|  |  |  | -1 |
|  |  |  | 0 |

### Hadron particles – Baryons

Formed by 3 quarks, with sum of charge being integer. (can’t be same 3 quark)

### Hadron particles – Mesons

Formed by quark & antiquark, with sum of charge being integer

### Electromagnetic force

Particles pass photons back and forth between each other

### Particle interactions

Finding momentum of particles after interaction

* , most energy converted to mass
* Leftover energy will be converted to

Interaction can only occur if all properties below are conserved

1. E, Q & p **Use vector diagram when explaining p**
2. Baryon number (is: 1, anti: -1, not: 0)
3. Lepton number (is: 1, anti: -1, not: 0)
4. Strangeness (is: -1, anti: 1, not: 0)

# Notes

### SI Base units

|  |  |  |  |
| --- | --- | --- | --- |
| Unit | Name | Quantity | Symbol |
| s | seconds | time | t |
| m | meter | length | l,x,d |
| kg | kilogram | mass | m |
| A | ampere | electric current | I |
| K | kelvin | temperature | T |
| mol | mole | amount of substance | n |
| cd | candela | luminous intensity | Iv |

### Personal notes: During exams…

* Make sure all squares in the formula are applied
* Draw vector diagrams
* If stuck, read question again for hidden details
* When explaining variable change be as precise as possible