1 Circular motion

1.1 Circular acceleration

1.1.1 Relations

$$a_c = \omega^2 r = \frac{v^2}{r} = \frac{4\pi^2 r}{T^2} = \omega v$$

$$\omega = \frac{2\pi}{T}$$

$$v = \omega r = \frac{2\pi r}{T}$$

1.2 Angular velocity

1.2.1 Definition

Angular displacement swept out by radius, per unit time.

2 Gravitational field & Electric field

2.1 Electric field

2.1.1 Definitions

- **A field of force**: *region of space where a particle experiences a force*

2.2 Gravitational field

2.2.1 Definition

- **A line of force in a gravitational field**: *Tangent to line gives direction of force on a mass*
- **A line of force in a electric field**: *Tangent to line gives direction of force on a positive charge*

2.2.2 Why gravitational potential is negative

- gravitational potential at infinity is zero
- gravitational force is attractive so work was done as objects move from infinity

2.2.3 Difference between gravitation field and electric field

- Gravitational force always attractive
- Electric field forces are attractive or repulsive

3 Capacitor

3.1 Capacitor

3.1.1 Function of capacitor

- Storage of energy
- Smoothing
- Blocking of direct current
- Producing of electrical oscillation

3.1.2 Why capacitor stores energy, no charge

- Positive and negative charges are separated, work done to achieve this, so stores energy
- The two plates have equal and opposite charges, so resultant charge is zero

3.2 Capacitance

3.2.1 Definition

Charge / Potential difference. [1]
The ratio of charge on one plate to the potential difference between plates. [2]

$$Q = CV$$

3.2.2 Capacitance is a property

$$C = \frac{\epsilon_0 A}{d}$$

where A is the area of one of the plates, and d is the plate separation.

3.2.3 Capacitance of a parallel capacitor

The ratio of charge on one plate to the potential difference between plates.

3.3 Energy stored in capacitors

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

3.3.1 The [?, half] comes in because

When the first change flows onto the capacitor plates, there is no p.d. opposing the flow.
As more charge flows, the p.d. increases, so more work is done
The average p.d. is equal to half the maximum p.d.

3.4 Parallel and series

3.4.1 Capacitor in parallel

V is constant, therefore $C_{total} = \sum_i^n C_i$

3.4.2 Capacitor in series

Q is constant, therefore $\frac{1}{C_{total}} = \sum_i^n \frac{1}{C_i}$

4 Oscillation

4.1 Oscillation

4.1.1 Definition

Backward and forward motion between two limits.

4.2 Properties

4.2.1 Angular frequency

$$\omega = \frac{2\pi}{T} = 2\pi f$$

4.3 Simple Harmonic Motion (SHM)

4.3.1 Definition

Motion of an oscillator in which its acceleration is directly proportional to its displacement from its equilibrium position and is directed towards that position.

$$F = -kx$$

$$ma = -kx$$

$$a = -\frac{k}{m}x$$

Also,

$$a = -\omega^2 x$$

It can be deduced that:

- $\frac{k}{m}$ **is constant**, *so acceleration is proportional to displacement*
- **Negative sign**, *so acceleration and displacement are in opposite direction*

4.4 Properties of an $a - x$ graph

- **A straight line through origin**, *so acceleration is proportional to displacement*
- **Negative gradient**, *so acceleration and displacement are in opposite diection*

$\omega^2 = -gradient$

4.5 $x - t$ graphs

$$v_{max} =$$

$\omega \mathrm{x}_0$

$$a = -\omega^2 x$$

$$v^2 = \omega^2(x_0^2 - x^2)$$

4.6 Energy in Oscillations

$$E = \frac{1}{2}mv^2 = \frac{1}{2}m(\omega r)^2$$

4.7 Damped oscillation

4.7.1 'Damped'

Loss of energy from an oscillation system, caused by force acting in opposite direction to the motion.

4.7.2 Amplifier-time graph

Amplitude reduced exponentially

4.7.3 Light damping

System oscillates about equilibrium position with decreasing amplitude

4.7.4 Over damping

4.7.5 Damping and resonance

- amplitudes decrease at all frequencies
- resonant frequency slightly decreases
- resonant peak becomes flatter

5 Magnetic Fields

5.1 Magnetic field

5.1.1 Definition

A region in which, a magnet, a current-carrying wire, or a moving charge, experiences a force.

5.1.2 Direction of field at a point

The direction of force acting on a North pole of needle at that point, tangent to the line.

5.1.3 Magnetic field strength

For single wire,

$$B = \frac{\mu_0 I}{2\pi r}$$

where $\mu_0 = 4\pi * 10^{-7}$

For solenoid coils,

$$B = \mu_0 I N$$

where N is the number of turns per unit length.

5.2 Magnetic flux density

5.2.1 Definition

Force acting per unit current on unit length of conductor, placed at right angle to the magnetic field

5.2.2 1 tesla

The magnetic flux density is 1T, when a wire carrying 1A current, placed at right angle to the magnetic field, will experience a force of 1N per metre.

5.3 Magnetic forces between two wires

$$F = BQv = BLv$$

$$R = \frac{mv}{BQ}$$

5.3.1 Why the path of the particle in the field is the arc of a circle

- Magnetic force is normal to velocity
- Speed is constant
- Magnetic force provides centripetal force

5.4 Velocity selector

5.4.1 Principle

- *Electric and magnetic field are normal to each other.*
- *Velocity is normal to the fields.*
- *Electric and magnetic forces are in opposite directions.*
- *When* $v = \frac{E}{B}$ *the two forces are equal.*

5.5 Hall Effect

5.5.1 Why constant V_H

- *Charge carriers moving normal to magnetic field*
- *experiences a force normal to* B *and* I
- *Charges build up at sides, to produce a voltage*
- *When electric force balanced magnetic force, the* V_H *reaches a constant value*

5.5.2 Why Hall Probe made of semiconductor

- *Hall voltage is inversely proportional to number density*
- *Semiconductor material has a lower number density*

5.5.3 Hall Probe is made of thin material

- *Hall voltage is inversely proportional to thickness of material*

6 Electromagnetic Induction

6.1 Cutting magnetic field

$$E = BLv$$

where v is the component normal to B.

6.2 Magnetic flux

6.2.1 Definition

$$\Phi = BA$$