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1 Further mechanics and thermal physics

1.1 Periodic motion

1.1.1 Circular motion

When there is motion in a circular path at constant speed, there is an acceleration and requires a centrepetal force.

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

One radian is the angle created where the arc length of a circle is equal to its radius.

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

$$F = \frac{mv^2}{r} = m\omega^2 r$$

1.1.2 Simple harmonic motion

An object moving in simple harmonic motion oscillates in equilibrium.
Simple harmonic motion is defined as:

$$a \propto -x$$

The acceleration of simple harmonic motion, $a = -\omega^2 r \cos\theta$ is the horizontal component of acceleration of circular motion $a = \omega^2 r$. Substituting $x = r\cos\theta$ gives,

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

$$x = A\cos(\omega t)$$

$$v = \pm\omega\sqrt{(A^2 - x^2)}$$

$$\text{Maximum speed} = \omega A$$

$$\text{Maximum acceleration} = \omega^2 A$$

1.1.3 Simple harmonic systems

A mass spring system is a simple harmonic oscillator. When a mass is pushed or pulled from either side of the equilibrium postion, there's a restoring force exerted on it.

$$T = 2\pi\sqrt{\frac{m}{k}}$$

A simple pendulum is a simple harmonic oscillator.

$$T = 2\pi\sqrt{\frac{l}{g}}$$

$$E_{k\ (max)} = E_{p\ (max)}$$

1.1.4 Forced vibrations and resonance

Free vibrations invovle no transfer of energy to or form the surroundings and oscillates at its resonant frequency. Forced vibrations happen when there's an external force. The frequency of a forced vibration is called the driving frequency.
A system is resonating when the driving frequency approaches the natural frequency. At resonance the phase difference between the driver and the oscillator is 90°. Damping forces cause oscillating systems to loose energy to their surroundnigs. Lightly damped systems take a long time to stop oscillating, heavily damped systems take a short time to stop oscillating. Critical dampening reduces the amplitude in the shortest possible time. Overdamped systems have heavier dampening than cirtically damped systems and take longer to return to equilibrium.

1.2 Thermal physics

1.2.1 Thermal energy transfer

1.2.2 Ideal gas

1.2.3 Molecular kinetic theory model

2 Feilds and their consequences

2.1 Fields

A force field is a region where a body experiences a non-contact force.

A force feilds can be represented as a vector.

Force fields arise from the interaction of mass, of static charge, and between moving charges.

Similarites between gravitiational and electric feilds:

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X|X Gravitational feilds Electric feidls

Gravitational feild strench, **g**, is force pur unit mass. Electric feild strength, **E**, is force per unit positive charge

Newton's law of gravitation for the force between two points of masses is an inverse square law. $F\frac{1}{r^2}$ Coulomb's law for the electric force betweeen two points changes is also an inverse square law. $F\frac{1}{r^2}$.

The gravitational field lines act towards the center of the feild for a mass The electric feild lines act towards the center of the field for a negative charge.

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2.2 Gravitational fields

2.2.1 Newton's law

2.2.2 Gravitational field strength

2.2.3 Gravitational potential

2.2.4 Orbits of planets and satelites

2.3 Electric fields

2.3.1 Coulomb's law

2.3.2 Electric field strength

2.3.3 Electric potential

2.4 Capacitance

2.4.1 Capacitance

$$C = \frac{Q}{V}$$

2.4.2 Parallel plate capacitor

$$C = \frac{A\varepsilon_0\varepsilon_1}{d}$$

Permittivity is a measure of how difficult it is to generate an elecric feild in a medium. Reletive permittivity is the ratio of permittivity of a material to the permittivity of free space. Reletive permittivity is also known as the dielectric constant.
Polar molecules rotate in an electric feild because the negative ends of the molecules are attracted to the positively charged plate.

2.4.3 Energy stored by a capacitor

The area under the graph of change against potential difference is the energy stored by the capacitor

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

2.4.4 Capacitor chrage and discharge

$t = RC$ is known as the constant, τ, which is them time taken for the charge on a dischargnig capacitor Q to fall $\frac{1}{\mathrm{e}}$ of Q_0 or the charge of a charging capacitor to raise by $1 - \frac{1}{\mathrm{e}}$ of \$Q$_0$\$
The time constant can be calculated directly form a graph of a capacitor charging or discharging.
The time to half,$T_{\frac{1}{2}}$ is the time taken for the charge, current or potential difference of a discharging capacitor to decrease by half of its initial value. The time to halve is given by:

$$T_{\frac{1}{2}} = \ln(2)RC$$

Calculating the charge of a discharging capacitor:

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

Calculating the voltage of a discharging capacitor:

$$V = V_0 \mathrm{e}^{-\frac{t}{RC}}$$

Calculating the current of a discharging capacitor:

$$I = I_0 \mathrm{e}^{-\frac{t}{RC}}$$

Calculating the charge of a charging capacitor:

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

Calculating the voltage of a charging capacitor:

$$V = V_0 (1 - \mathrm{e}^{-\frac{t}{RC}})$$

Calculating the current of a charging capacitor:

$$I = I_0 \mathrm{e}^{-\frac{t}{RC}}$$

2.5 Magnetic fields

2.5.1 Magnetic flux density

2.5.2 Moving charges in a magnetic field

2.5.3 Magnetic flux and flux linkage

2.5.4 Electromagnetic induction

2.5.5 Alternating currents

2.5.6 The operation of a transformer

3 Nuclear physics

3.1 Radioactivity

3.1.1 Rutherford scattering

3.1.2 α , β and γ radiation

3.1.3 Radioactive decay

3.1.4 Nuclear instability

3.1.5 Nuclear radius

3.1.6 Mass and energy

3.1.7 Induced fission

3.1.8 Safety aspects