UNIT 4

REVISION NOTES

1

Momentum

- P=mv   Units:- $kg.m.s^{-1}$ N.s
- In an isolated system momentum is always conserved
- $p_{before} = p_{after}$
- Newton 3 - "To every action there is an equal and opposite reaction."

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Newton 2

- "The rate of change of momentum of an object is proportional to the applied force and takes place in the direction of that force."

$$F = \frac{d(mv)}{dt}$$

- If mass is constant then F=ma

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Kinetic Energy

$$E_k = \frac{mv^2}{2}$$

- In an isolated system, energy is conserved.
- In an elastic collision, E_k before = E_k after.
- In an inelastic collision, E_k before > E_k after.
- In an explosive collision, E_k before < E_k after.
- Gravitational potential energy = mgh

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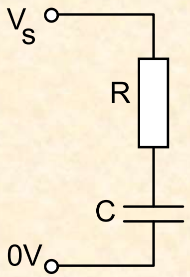
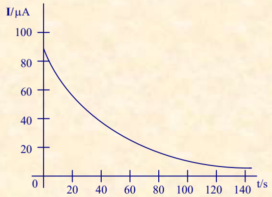
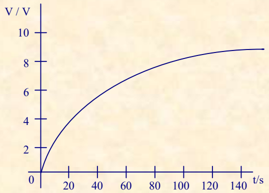
Capacitors 1

Capacitor  Farads



Capacitor charging current and voltage

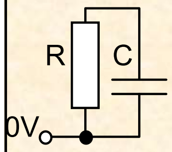


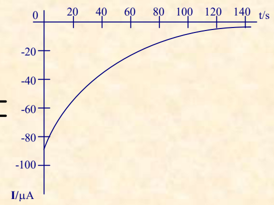


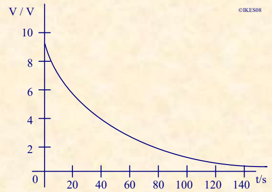
Practical units:- μF, nF, pF

Capacitors 2

Capacitor discharge current and voltage







- In series $\frac{1}{C_T} = \frac{1}{C_1} + \frac{1}{C_2}$
- In parallel $C_T = C_1 + C_2$

Capacitors 3

- Q = CV Coulombs
- Charge $V = V_s(1 - e^{-t/RC})$
- Discharge $V = V_s e^{-t/RC}$
- Time Constant T = RC
  - Time to charge to $0.63V_s$
  - Time to discharge to $0.37V_s$
- Time to charge to $0.5V_s$=0.69RC
- Time to fully charge or discharge = 5RC

Capacitors 4

- Energy stored in a capacitor is equal to the area under a Q v V graph.
- W = ½QV = ½CV^2 = ½Q^2/C
- Energy supplied is 2x the energy stored when charged from a fixed voltage.

Magnetic Fields

- Direction from N => S
  - (motion of isolated N pole)
- Continuous loops – do not cross.
- Neutral points
- Φ magnetic flux   Webers Wb
- B magnetic flux density Tesla T
- $B = \Phi/A$ ($\Phi = BA\sin\theta$)
- $N\Phi$ magnetic flux linkage

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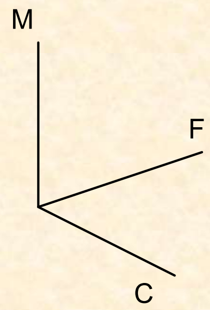
Fleming's Left Hand Rule

Motor Rule



- $F = BIL\sin\theta$
- $F = Bqv\sin\theta$
- Conventional current flow

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Electromagnetic Induction

- When there is a change in flux linkage between a conductor and magnetic field, a voltage is induced in the conductor.
- Faraday's Law of Electromagnetic Induction:
  - $\varepsilon = {}^{d(N\Phi)}/_{dt}$
- Lenz's Law – conservation of energy
- "The induced voltage always opposes the effect producing it.
- $\varepsilon = -{}^{d(N\Phi)}/_{dt}$

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Electric Fields 1

- Start on a + charge and end on a – charge
- + ⇨ – Motion of an isolated + charge.
- Lines do not cross. Neutral points.
- Radial field?   Uniform field?
- Electric field strength, $E = F/Q = V/d$
- Units $N.C^{-1}$ and Vm^{-1}

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Electric Fields 2

- Coulomb's law $F = \frac{Q_1 Q_2}{4\pi \varepsilon_0 r^2}$
- Electric field intensity of a point charge

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

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Thermionic Emission

- Electrons emitted from hot metal surface.
- Charged particles accelerated by electric field.
  - $E_k = ½mv^2 = qV$ (for v << c)
- Charged particles deflected by electric field.
  - parabola
- Charged particles deflected by magnetic field.
  - circular path.
  - $E_k = p^2/2m$ (for v << c)

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Particle Collisions

- Energy and momentum conserved.
  - Elastic collisions
- 1d – as normal collisions.
- 2d – resolve into 2 directions at 90°
  - Apply p conservation independently.
- $v_x = v\cos\theta$, $v_y = v\sin\theta$, Pythagorous.
- Identical masses – angle after = 90°
- Heavy hits light - angle after < 90°
- Light hits heavy - angle after > 90°

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Angular Motion

- Π radians = 180°
  - θ = angular displacement, rad.
  - ω = angular velocity rad.s^{-1}
- v = ωr T = 2π/ω
- Centripetal force = $mv^2/r = mr\omega^2$
  - directed towards the centre of the circle
- Centripetal acceleration = $v^2/r = r\omega^2$

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Particle Accelerators

- Linear – high voltage.
  - operation
  - advantages
  - disadvantages
- Linac.
  - operation
  - advantages
  - disadvantages
- Cyclotron
  - operation $r = p/BQ$
  - advantages
  - disadvantages

Particle Detectors

- spark, gm tube, ionisation chamber
- Chambers
  - spark, cloud, bubble, drift
- Only charged particles produce tracks
- Magnetic fields to differentiate charges
- $r = p/Bq$

Particle Interactions

- Momentum, Energy and Charge conserved.
- $E = \Delta mc^2$
- Electron-volt eV = $1.6\text{x}10^{-19}$J   ($E=qV$)
- keV, MeV, GeV
- Mass MeV/c^2, GeV/c^2 ($1.78\text{x}10^{-27}$kg)
- amu 1/12 ^{12}C ($1.66\text{x}10^{-27}$kg)
- Nucleon number (mass number)
- Proton number (atomic number)
- Rutherford experiment – nuclear atom

Nuclear Particles

- Leptons (12 in total)
  - electron (e^-), positron (e^+), neutrinos (v) etc
- and Hadrons (quarks) (12 in total)
  - up, down, strange, charm, bottom, top
  - Baryons (3 quarks)   proton , neutron etc
  - Mesons (a quark and an antiquark)
  - pion (π^+, π^0, π^-),   etc
- In interactions, charge and baryon number are conserved.
- Energy loss forms new particles

Quarks

Name	Symbol	Charge	Mass
Down	**d**	$-^1/_3 e$	0.008
Up	**u**	$+^2/_3 e$	0.004
Strange	**s**	$-^1/_3 e$	0.15
Charm	**c**	$+^2/_3 e$	1.5
Bottom	**b**	$-^1/_3 e$	4.5
Top	**t**	$+^2/_3 e$	180

Leptons

Name	Symbol	Charge	Mass
Electron	e^-	-e	0.511
Neutrino	ν_e	0	$<3x10^{-6}$
Muon	μ^-	-e	105.7
Neutrino	ν_μ	0	<0.19
Tau	τ^-	-e	1777
Neutrino	ν_τ	0	<18.2

Particles or Waves

- de Broglie $\lambda = h/p$
- Evidence
  - electron diffraction
  - photoelectric effect

Prefixes

- tera ×1,000,000,000,000 (T) TeV
- giga ×1,000,000,000 (G) GeV
- mega ×1,000,000 (M) MHz, M
- kilo ×1,000 (k) kHz, k, kV

- milli ×0.001 (m) mV, mA, mW
- micro ×0.000 001 (μ) μV, μA, μW, μF
- nano ×0.000 000 001 (n) nF
- pico ×0.000 000 000 001(p) pF

Questions

- Set in context – read the context – underline relevant details.
- Look carefully at diagrams – circle and name relevant details.
- Focus on relevant bookwork descriptions and calculations – answer these.
- Attempt all sections – no credit can be given if there is no attempt at an answer!!!!!!!!
- *Estimate*, *Calculate* – show your working.
- *State and explain* – do both!