Course Notes: Pearson Edexcel International A Level Physics

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Contents

1 Physics Year 1

Consider a constant force $\vec{F}$ causing a ball of mass m which is moving at a velocity $\vec{v}$ to come to rest over a distance $\vec{s}$.

TODO: TikZ diagram

Using SUVAT:

$$v^2 = u^2 + 2as \tag{1}$$

But since it comes to rest, $v = 0$, and the initial velocity $u = |\vec{v}|$. Rearranging for a:

$$
\begin{aligned}
0 &= v^2 + 2as \\
v^2 &= -2as \\
-\frac{v^2}{2} &= as \\
as &= -\frac{v^2}{2} \tag{2}
\end{aligned}
$$

Since the work done W by a constant force is given by:

$$W = \vec{F} \cdot \vec{s} = m\vec{a} \cdot \vec{s} \tag{3}$$

We can substitute equation 2 into this to get something already resembling the kinetic energy formula:

$$
\begin{aligned}
W &= m \cdot -\frac{v^2}{2} \\
W &= -\frac{1}{2}mv^2
\end{aligned}
$$

Since the work done W is equal to the change in kinetic energy, and the particle ends at rest, we have:

$$
\begin{aligned}
W &= E_{kf} - E_{ki} \\
W &= 0 - E_{ki} \\
W &= -E_{ki} \\
E_{ki} &= -W \\
E_{ki} &= \frac{1}{2}mv^2
\end{aligned}
$$

# 2 Physics Year 2

5 Further Mechanics

5B Circular Motion

5B.1 Proof of $a = -\frac{v^2}{r}$ during Uniform Circular Motion

During uniform circular motion, an object moves in a circle of radius r at a constant speed v and constant angular velocity ω. Although the speed is constant, the direction of the velocity vector is continuously changing, which means the object is accelerating.

The equation for the magnitude of the centripetal acceleration a is given by:

$$a = \frac{v^2}{r} \tag{4}$$

Here is a proof of this formula, with help from a diagram.
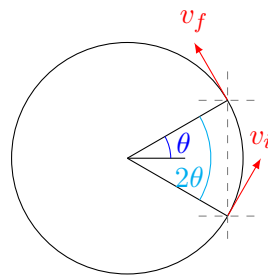
By definition,

$$a = \lim_{\Delta t \to 0} \frac{\Delta v}{\Delta t} \tag{5}$$

Noticing that since there is no change in the y-component of v_i and v_f, the acceleration in the y-direction is zero. Therefore, we only need to consider the x-component of the velocity. Thus:

$$a = a_x = \lim_{\Delta t \to 0} \frac{\Delta v_x}{\Delta t} = \lim_{\Delta t \to 0} \frac{v_{fx} - v_{ix}}{\Delta t}$$

By trigonometry, we can see that:

$$
\begin{aligned}
v_{ix} &= v \sin\theta \\
v_{fx} &= -v \sin\theta
\end{aligned}
$$

And from the definition of angular velocity, we know that:

$$\omega = \frac{\Delta\theta}{\Delta t}$$

$$\omega = \frac{2\theta}{\Delta t}$$

$$\Delta t = \frac{2\theta}{\omega}$$

Now, work out the limit:

$$a = \lim_{\Delta t \to 0} \frac{-v\sin\theta - v\sin\theta}{\Delta t}$$

$$a = \lim_{\Delta t \to 0} -\frac{2v\sin\theta}{\Delta t}$$

$$a = -\lim_{\theta \to 0} \frac{2v\omega\sin\theta}{2\theta}$$

$$a = -\lim_{\theta \to 0} v\omega \cdot \frac{\sin\theta}{\theta}$$

$$a = -v\omega \cdot \lim_{\theta \to 0} \frac{\sin\theta}{\theta}$$

$$a = -v\omega \cdot 1$$

$$a = -v\omega \cdot 1$$

Now finally, since $v = r\omega$, we can substitute for ω:

$$a = -v \cdot \frac{v}{r}$$

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

Now for completeness, this is actually the acceleration in the x-direction. In this case, the x-direction is towards the center of the circle, so the negative sign indicates that the acceleration is centripetal. But the magnitude of the acceleration is of course positive.

6 Electric and Magnetic Fields

6C Electromagnetic Effects

Gravitational, electric and magnetic fields are all vector fields. The strength of each field is defined as the force per unit something experienced by an object placed in the field:

$$\vec{g} = \frac{\vec{F}}{m} \qquad \vec{E} = \frac{\vec{F}}{q} \qquad \vec{B} = \frac{\vec{F}}{q\vec{v}}$$

$$\Phi = \frac{W}{m} \qquad V = \frac{W}{q} \qquad ? = \frac{W}{q\vec{v}}$$
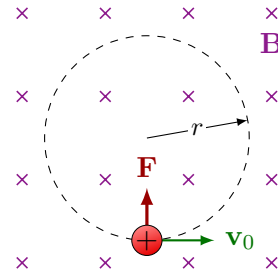
Or V_{grav}

$$W = \vec{F} \cdot \vec{s}$$

$$W = |\vec{F}|\,|\vec{s}|\cos\theta$$

Magnetic fields can cause circular motion!

The forces involved are the magnetic force and the centripetal force:

$$\vec{F}_B = q\vec{v} \cdot \vec{B} \qquad \vec{F}_{cr} = \frac{m\vec{v}^2}{r}$$

Equating the magnetic force to the centripetal force, we can solve for the radius of the circular path:

$$q\vec{v} \cdot \vec{B} = \frac{m\vec{v}^2}{r}$$

$$q\vec{B} = \frac{m\vec{v}}{r}$$

$$r = \frac{m\vec{v}}{q\vec{B}}$$

$$r = \frac{\vec{p}}{q\vec{B}}$$

See also

- Raycast AI Chat, Gemini 2.5 Pro: Electromagnetic Induction and Magnetic Forces: Equations, hints, and problem-solving

Magnetic flux through an area A in a magnetic field B is given by:

$$\Phi = \vec{B} \cdot \vec{A}$$
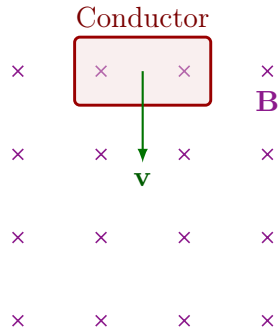
$$\Phi = |\vec{B}|\,|\vec{A}|\,\cos\theta$$

Where Φ is in webers, Wb, or $\mathrm{T\,m^2}$, since B is in teslas and A is in square metres.
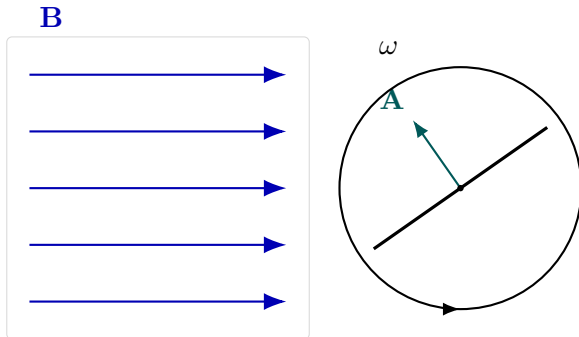
More magnetic flux stuff:

$$\frac{\mathrm{d}}{\mathrm{d}t}\Phi = V$$

$$\frac{\mathrm{d}}{\mathrm{d}t}N\Phi = V$$

"The rate of change of flux linkage through a coil gives the induced e.m.f. across the coil."

Conductor

Or we can have induction with a rotating coil in a magnetic field:

Here, e.m.f. is given by:

$$\mathcal{E} = \frac{\mathrm{d}}{\mathrm{d}t}[N\Phi] \tag{6}$$

Taking out the constants, rearranging and substituting:

$$\mathcal{E} = N\frac{\mathrm{d}\Phi}{\mathrm{d}t}$$

$$\mathcal{E} = N\frac{\mathrm{d}}{\mathrm{d}t}\left(\vec{B}\cdot\vec{A}\right)$$

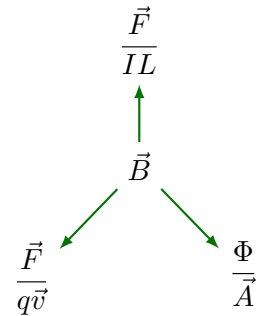$$\mathcal{E} = N\frac{\mathrm{d}}{\mathrm{d}t}\left(|\vec{B}|\,|\vec{A}|\,\cos\theta\right)$$

Using $A = |\vec{A}|$ and $B = |\vec{B}|$ for simplicity:

$$\mathcal{E} = N\frac{\mathrm{d}}{\mathrm{d}t}(BA\cos\theta)$$

$$\mathcal{E} = NBA\frac{\mathrm{d}}{\mathrm{d}t}[\cos\theta]$$

$$\mathcal{E} = NBA\frac{\mathrm{d}}{\mathrm{d}t}[\cos\omega t]$$

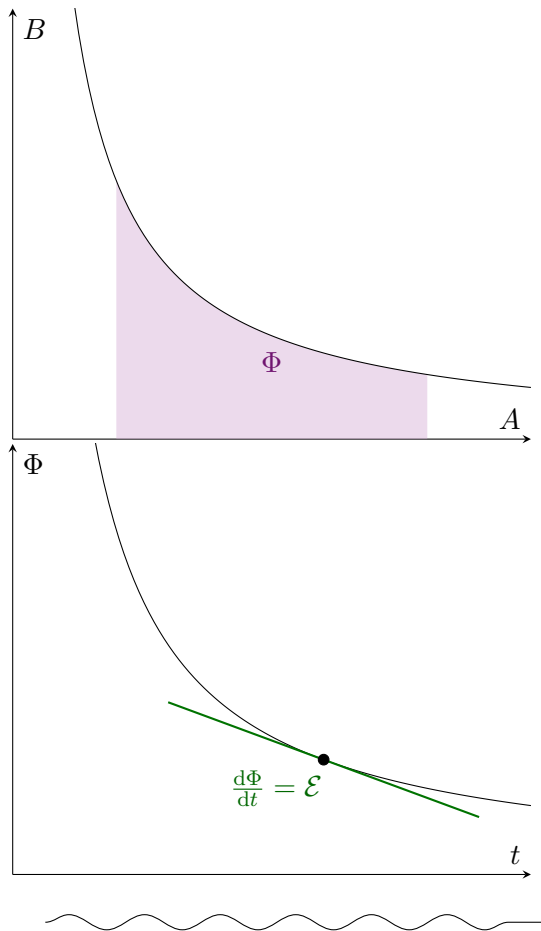$$\mathcal{E} = -NBA\omega\sin(\omega t)$$

Therefore,

$$\vec{F} = \vec{B}IL$$

$$\vec{F} = q\vec{v}\cdot\vec{B}$$

4

From the diagram, we can see that the magnetic flux Φ through each coil is the same. Therefore, we can write the e.m.f.s in each coil as:

$$\mathcal{E}_p = -N_p\frac{d\Phi}{dt}, \quad \mathcal{E}_s = -N_s\frac{d\Phi}{dt} \tag{8}$$

Taking the ratio of these two equations gives us equation 7:

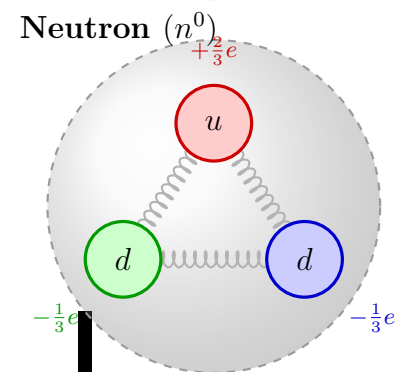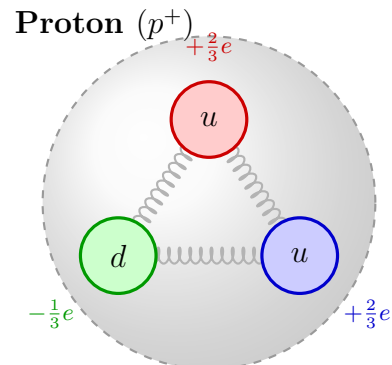$$\frac{\mathcal{E}_p}{\mathcal{E}_s} = \frac{N_p}{N_s} \tag{7 revisited}$$

7 Nuclear and Particle Physics

7C The Particle Zoo

"Hadrons are subatomic particles made of quarks, which experience a Strong Nuclear Force."

"Quark flavour changing is done by the Weak Nuclear Force."

Proton (p^+)

Neutron (n^0)
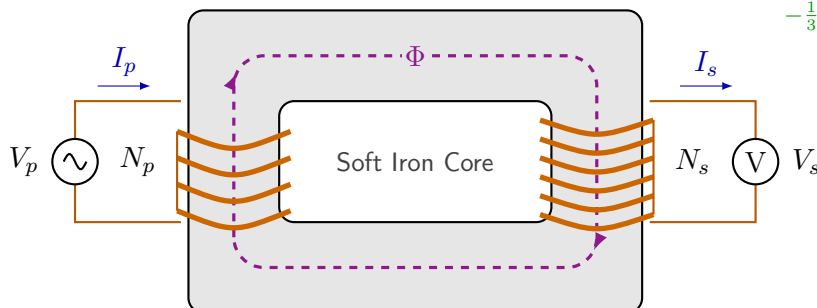

B

Φ

$$\frac{d\Phi}{dt} = \mathcal{E}$$

TRANSFORMERS!!!

Ratio of primary to secondary e.m.f.s is equal to the ratio of the number of turns in the primary to the secondary coil.

$$\frac{\mathcal{E}_p}{\mathcal{E}_s} = \frac{N_p}{N_s} \tag{7}$$

This equation can be derived using the following diagram of a transformer and the definition of e.m.f. seen in equation 6:

A   List of Equations

AA   Waves

- $v = \lambda f$
- $v^2 = \frac{T}{\mu}$ in a uniform string/rope

Force of tension → T

Linear density → μ
in $\mathrm{kg\,m^{-1}}$

Interference:

- p.d. $= n\lambda$ ← constructive

- p.d. $= \left(n + \frac{1}{2}\right)\lambda$ ← destructive

AB   Photoelectric Effect

- $h = 6.63 \times 10^{-34}\,\mathrm{J\,s}$

- $E = hf$

- $hf = \phi + E_{k\mathrm{max}}$

- $V = \frac{W}{Q} \iff W = QV$

B   List of Definitions

BA   Circuits

e.m.f.

- Energy supplied per unit charge
- Work done per unit charge
- The work done moving unit charge around the whole circuit

C   Textbook

The textbook pages are omitted in draft mode.