Transformers * ½

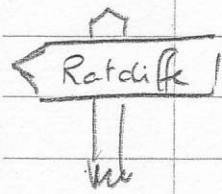
A Physics

* R____ in D____ !

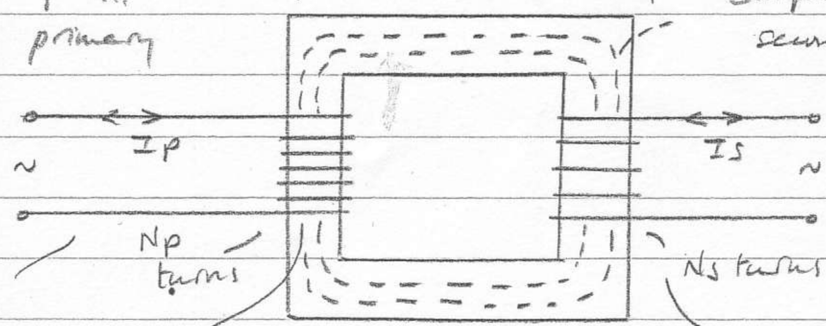
pure Fe – minimum energy to reverse magnetic field

– Iron core – laminated (solenoid) to reduce eddy currents.

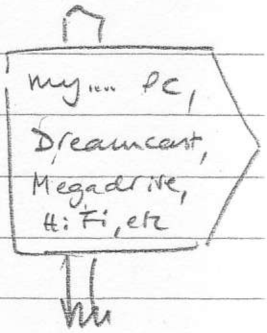
some flux escapes



Input... primary



output secondary



changing current in primary... ...produces changing magnetic field... ...in iron core, which links both coils, and... ...changing field in secondary coil induces emf/current.

- A transformer passes on electrical energy from one circuit to another via a magnetic link
- Ideal transformers are 100% efficient. For real transformers....

flux escapes – magnetic field – energy losses – heating

energy needed to keep reversing the magnetic field – magnetic field

heating – due to electric current in.... – copper coils – iron core (eddy currents)

- Transformers are brilliant for changing voltages

eg step up... $N_p < N_S$ – changing flux induces a small emf across each coil in the secondary.
- more coils ⟶ bigger total emf
- BUT... you get a smaller current

Step down $N_p > N_S$.

Current, voltage + power.

1. Turns ratio $\frac{V_s}{V_p} = \frac{N_S}{N_p}$ so... twice as many turns on sec. → 2x the voltage out

2. Power $P_{in} = 1\ J/s = P_{out} = 1\ J/s$ for 100 % efficiency

but $P_{in} = I_p V_p = I_S V_s = P_{out}$ If you 2x voltage current halves, to keep Power the same

for a step up transformer.... same number of Joules/sec out, but "carried" by fewer Coulombs of charge... less current ... less heating ©

TJH 4.00

A2 Physics

Transformers + Energy Losses ....
... and Lenz's Law

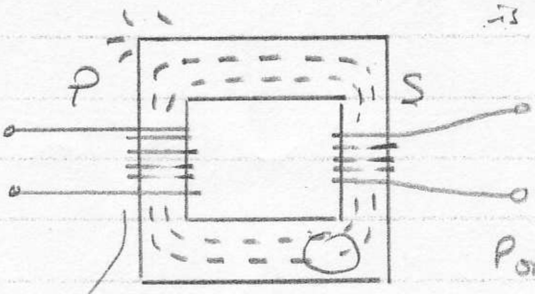
A. Transformers

1. Some magnetic flux "leaks" out of the core – so they make the core out of overlapping pieces of iron

2. Energy lost in reversing the mag. field in the core – so they make it of iron/silicon – which is easily magnetised.

240 V

50 mA



8 V.

1.25 A

P_{in} =

P_{out} =

Efficiency =

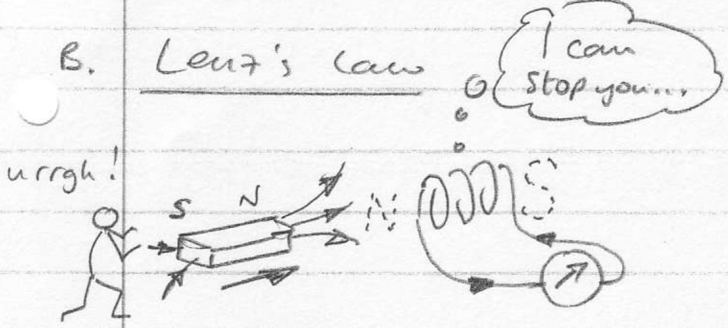
3. Energy lost as heat in the coils – so ↑d ... ↓R
Heating power loss $P = IV = I^2R$
and $R = \rho l / A$ ... so there you are!

4. Changing mag. field in the core induces eddy currents in the core – so, slice the core into thin strips – laminated – like Dairylea


solid core – big currents → big heat loss


laminated – small currents → small heat loss.

B. Lenz's Law



Push the magnet.... coil "feels" mag. flux changing through itself...
this induces an emf ($E = (\frac{\Delta\Phi}{t})N$) and a current flows ...
... and the DIRECTION of the induced current produces an electromagnetic field that OPPOSES the motion of the magnet
If the current direction was t'other way....
So the system resists change.

Damping


coil in mag. field
Induced current
opposes motion – scale settles quickly

JJN
May '02