InkPhysics

ANSWER BOOK

Transformers

Magnetic fields · Year 13

AQA 3.7.5.6 · OCR A 6.3.3(f)(i)

18 questions · 48 marks

NAVY EDITION

SECTION A · Warm-up

A1 The alternating current in the primary produces a continually changing magnetic flux in the iron core, which links the secondary coil (1); by Faraday's law the changing flux linkage induces an alternating emf in the secondary, so energy is transferred without an electrical connection (1). [2]

A2 $V_s = V_p \times N_s/N_p = 230 \times 100/1000$ (1) [2]
$V_s = 23$ V (1)

A3 Step-down: the secondary voltage is lower than the primary voltage (1). [1]

A4 A steady current produces a constant flux in the core (1); with no change in the flux linkage of the secondary, no emf is induced (1). [2]

A5 Any two of the following, one mark each (2): resistance of the windings heating the coils; eddy currents induced in the core; flux leakage, with some flux missing the secondary; energy used in repeatedly magnetising the core each cycle. [2]

A6 $N_p/N_s = V_p/V_s = 230/5.0$ (1) [2]
$N_p{:}N_s = 46{:}1$ (1)

SECTION B · Standard

B1 $N_s = N_p \times V_s/V_p = 2000 \times 12/240$ (1) [2]
$N_s = 100$ turns (1)

B2 $P = V_pI_p = 230 \times 2.0 = 460$ W (1) [3]
Ideal, so $V_sI_s = V_pI_p$ (1)
$I_s = 460/23 = 20$ A (1)

B3 Efficiency = output power/input power = 450/500 (1) [2]
Efficiency = 0.90 (90%) (1)

B4 $I_p = V_sI_s/V_p = (1150 \times 0.40)/230$ (1) [2]
$I_p = 2.0$ A (1)

B5 Eddy currents are currents induced in the iron core itself by the changing flux (1); they dissipate energy by heating the core as they flow through its resistance (1); the core is made of thin laminations separated by insulation, which break the current loops into small ones and greatly reduce the loss (1). [3]

B6 The core carries the same changing flux through every turn of both coils (1); by Faraday's law each turn therefore has the same rate of change of flux, so the same emf is induced in every turn (1); the total voltage across each coil is the emf per turn multiplied by its number of turns, so the voltages are in the ratio of the turns (1). [3]

B7 Input power = 230 × 0.26 = 59.8 W (1) [4]
Output power = 11.5 × 4.6 = 52.9 W (1)
Efficiency = 52.9/59.8 = 0.88 (88%) (1)
Power dissipated = 59.8 - 52.9 = 6.9 W (1)

SECTION C · Stretch

C1 At 10 kV: I = P/V = 100000/10000 = 10 A (1) [4]
Loss = $I^2R = 10^2 \times 5.0$ = 500 W (1)
At 100 kV: I = 1 A, so loss = $1^2 \times 5.0$ = 5 W (1)
Raising the voltage by a factor of 10 cuts the current by 10 and the loss by 100 (1).

C2 Input power = 230 × 5.0 = 1150 W (1) [3]
Output power = 0.96 × 1150 = 1104 W (1)
I_s = 1104/46 = 24 A (1)

C3 For a given power, a higher voltage means a smaller current, since P = VI (1); the power wasted heating the cables is I^2R (1); reducing the current therefore greatly reduces the losses, making transmission more efficient (1). [3]

C4 $V_s = V_p \times N_s/N_p$ for each transformer (1) [4]
T1: V_s = 230 × 52/1000 = 12.0 V (1)
T2: V_s = 13.8 V and T3: V_s = 9.2 V (1)
Only T1 gives an output between 11.5 V and 12.5 V, so T1 is the suitable transformer (1)

C5 V_s = 230/10 = 23 V (1) [4]
$I_s = V_s/R$ = 23/4.6 = 5.0 A (1)
Ideal, so $I_p = V_sI_s/V_p$ (1)
I_p = (23 × 5.0)/230 = 0.50 A (1)