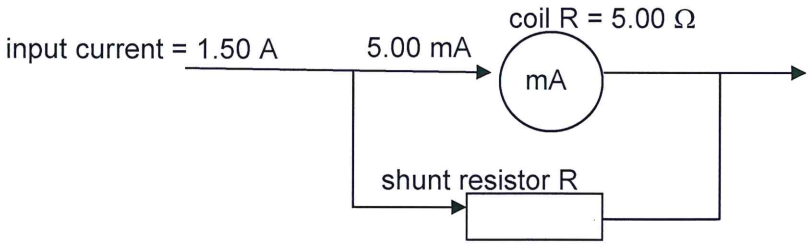
Exam Answers
Chapter 5·3 - Transformers
Answer 1 2010:1:11

(5 marks)

The ammeter shown below can be used to measure a range of electric currents up to 500 mA by selecting the appropriate terminals.

The coil inside the meter is not designed to take large currents. If the ammeter is required to measure a maximum reading of 1.50 A, an additional resistor called a *shunt* has to be added as shown below. The meter has a coil resistance of 5.00 Ω. This arrangement is shown here:



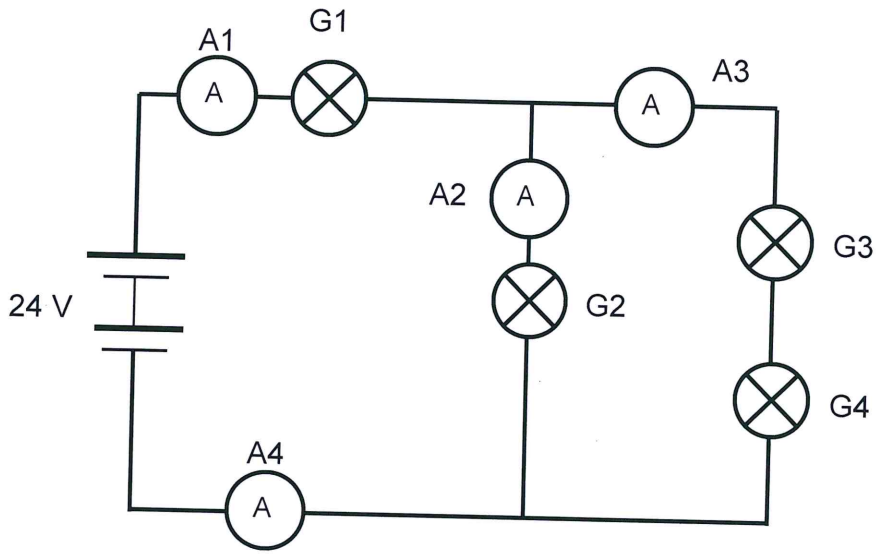
Find the value of the shunt resistor R.

Description	Marks
Current through shunt = 1.50- 0.005 = 1.495 A	1
Demonstrate understand voltage across shunt and meter are identical.	1
V =IR	1
Therefore 1.495 × R = 0.005 × 5	1
R = 1.67×10^{-2} Ω	1
	Total 5

Exam Answers
Chapter 5.3 - Transformers
Answer 2 2010:2:18

(14 marks)

Four identical light globes, G1, G2, G3 and G4, are connected in a circuit as shown below. The DC supply voltage is 24.0 V and ammeter A3 connected in the circuit reads 0.096 A.



(a) Calculate the current in each of the ammeters A1, A2 and A4. (3 marks)

Description	Marks
A2 = 2 × 0.096 = 0.192 A (since resistance path has half the resistance of G3, G4)	1
A4 = A1= A 2 + A3 =0.192 + 0.096 = 0.288 A	1–2
Total	**3**

(b) Calculate the resistance of each light globe. (3 marks)

Description	Marks
Calculation of networks total resistance as 5R/3	2
Recall current thru" G2 is 0.192 A so current in A1 is 0.288 A	
Sub 24 = 0.288 5R/3 to give R = 50 Ω	1
Total	**3**

(c) Which light globe will be the brightest? Justify your answer. (2 marks)

Description	Marks
G1	1
Reason, splits after G1 so **G1 has the largest current**	1
Total	**2**

Exam Answers
Chapter 5.3 - Transformers
Answer 2 continued

(d) Calculate the total power consumed by all four light globes. If you were unable to determine an answer to part (a) you should assume the current in ammeter A4 is 0.300 A. (2 marks)

Description	Marks
Power G1 = $(0.288)^2 \times 50 = 4.15$ W G2 = $(0.192)^2 \times 50 = 1.84$ W G3 = G4 = $(0.096)^2 \times 50 = 0.46$ W	
Total is 4.15 +1.84 +0.46 + 0.46 = 6.91 W	1-2
Or P=I.V = 0.288 × 24 =6.91 W	**Or** 1 1
Total	**2**

If use 0.30A then solutions are G1 = $(0.30)^2 \times 50 = 4.50$W G3 = G4 = 0.46 W, as before
G2 = $(0.204)^2 \times 50 = 2.08$ W total = 7.50 W (2 marks)
Or P= VI = 7.20W

(e) If globe G3 is broken, describe how the brightness of each of the light globes G1 and G2 changes. Give a reason in each case. (4 marks)

Description	Marks
If G3 is broken then circuit resistance is 2R (100 Ω) instead of 5R/3 so current is reduced in G1 to 0.24 A.	
Current in G2 is increased from 0.192 A to 0.24 A so **G2 is BRIGHTER**.	1-2
Current in G1 is reduced from 0.288 A to 0.24 A so **G1 is DULLER**.	1-2
NB: calculations are not required but it is difficult to work out the answers without them.	
Total	**4**

Exam Answers
Chapter 5.3 - Transformers
Answer 3 2010:3:22

(13 marks)

Generation and Transmission of Electricity

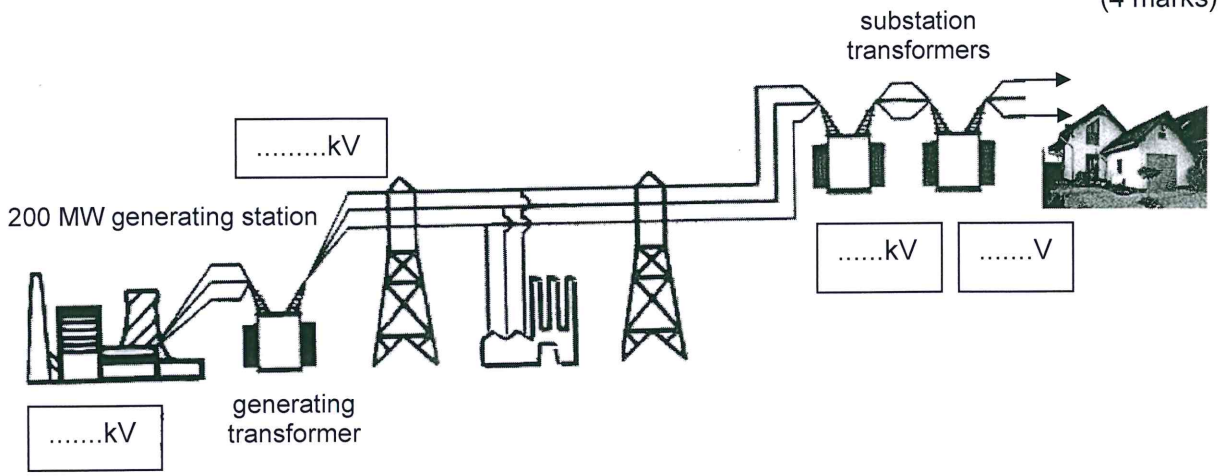
Approximately 30 per cent of the energy used in Australia is generated by power stations. The largest power station in Western Australia is Muja, which is situated close to the coalmining town of Collie.

At Muja coal is ground to the consistency of powder and then burned to heat water until it turns to steam. Steam at a temperature of 540°C and pressure of 16 MPa is used to drive turbines at a rate of 3000 revolutions per minute.

Muja power station generates at a total rate of 1040 MW from its 8 generators. There are four 60 MW generators and four 200 MW generators. The 60 MW generators produce power at 11.8 kV and the 200 MW generators produce power at 16 kV. Generators feed the electricity produced into transformers where the voltage can be increased or decreased.

Before the electricity is distributed, transformers are used to step up the voltage to 330 kV. High voltage transmission has advantages in reducing energy lost due to the resistance of the transmission lines. On the outskirts of Perth there is a substation that reduces the voltage to 11 kV and in the local park is a further small transformer that reduces the voltage to 240 V.

(a) On the diagram below show the voltages at the different stages of the transmission. (4 marks)



Description	Marks
Each error subtract 1 mark (minimum mark of zero)	1–4
	Total 4

(b) Explain why the generator is designed to produce alternating current and not direct current. (2 marks)

Description	Marks
Key idea is that **a transformer works on AC** and not DC and transformers are required throughout the transmission process **to change voltages**.	1–2
	Total 2

Exam Answers
Chapter 5·3 - Transformers
Answer 3 continued

(c) Calculate the current generated in one of the 200 MW generators. (2 marks)

Description	Marks
$P = I.V$ $200 \times 10^6 = 16 \times 10^3 \times I$	1
$I = \frac{200 \times 10^6}{16 \times 10^3} = 1.25 \times 10^4$ A	1
	Total 2

(d) Explain why the voltage is increased to 330 kV before it is distributed to users. (2 marks)

Description	Marks
Key idea is that if high voltage is used then the same power can be transmitted at a lower current	1-2
If the transmission current is reduced then the losses $I^2 R$ are reduced significantly	
	Total 2

(e) Calculate the turns ratio of a transformer being used to increase the voltage from a 60 MW generator to 330 kV. (2 marks)

Description	Marks
Recall $\frac{V_s}{V_p} = \frac{N_s}{N_p}$	1
Substitute 330 kV / 11.8 kV = Turns ratio= 28 (for primary to secondary)	1
	Total 2

(f) Suggest a possible difference between the 60 MW and the 200 MW generators that would result in a difference in output voltage. (1 mark)

Description	Marks
Either more turns on the coil or a stronger magnetic field. Not different rotation frequency or larger armature.	1
	Total 1

Exam Answers
Chapter 5.3 - Transformers
Answer 4 2011:2:18

(13 marks)

This photograph shows the information on a compliance plate on the outside of a small transformer used in a house in another country.

(a) Determine the ratio of windings of primary:secondary coils in the transformer. (2 marks)

Description	Marks
$V_p:V_s = N_p:N_s$	1
120:9 or 40:3 or 13.3:1	1
	Total 2

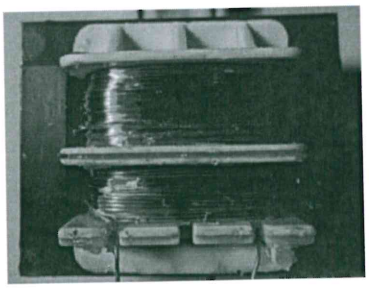
(b) Using the information on the compliance plate, calculate the power output of the transformer and use this information to determine the percentage efficiency of the transformer. (3 marks)

Description	Marks
$P_s = VI = 9 \times 0.500$	1
$P_s = 4.5$ W	1
efficiency $= \frac{4.5}{9} \times 100 = 50\%$	1
	Total 3

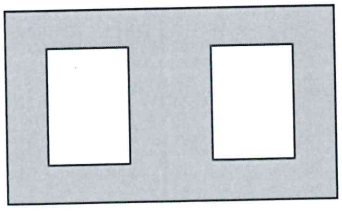
(c) Explain why the input voltage must consist of an alternating current rather than of direct current. (2 marks)

Description	Marks
There is no changing voltage/current with DC so no changing flux	1
To induce a current in the secondary coil there should be a changing flux	1
	Total 2

(d) The following photograph shows the coils and core inside the transformer case.



For small commercial transformers, the coils are placed around the centre pillar of the core, which is shaped like this:



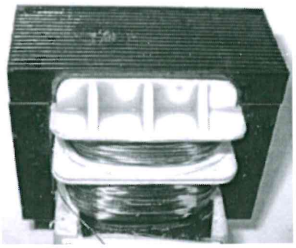
Describe the purpose and properties of the core. (2 marks)

Description	Marks
Purpose: Direct and strengthen the flux	1
Properties: Soft (non-permanent ferromagnetic) material and laminated	1
	Total 2

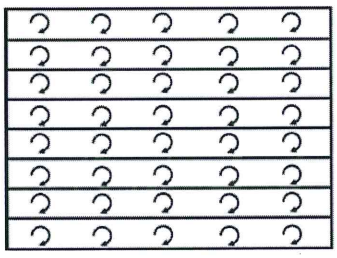
Exam Answers
Chapter 5·3 - Transformers
Answer 4 continued

(e) The photograph below shows the laminae (a number of thin iron sheets separated by non-electrically conductive material, such as plastic) that make up the core. These laminae are used to reduce 'eddy currents' or 'back emf' and make transformers more efficient.

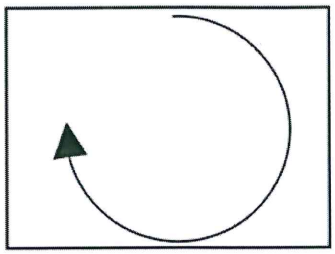
Use the following diagrams representing the centre pillar of the transformer and any relevant formula to explain why a transformer with a laminated core is more efficient than a transformer with a solid core. (4 marks)



Laminated core



Solid core



Description	Marks
Changing magnetic field induces emf in the iron core, large current if not laminated.	1
Relates induced/eddy current to cross sectional area	1
A laminated core increases the efficiency of transformer by *reducing* induced or eddy currents	1
Uses the diagram to show a difference in sizes current (eg little loops vs big loops)	1
	Total 4

Answer 5 2013:1:3

(3 marks)

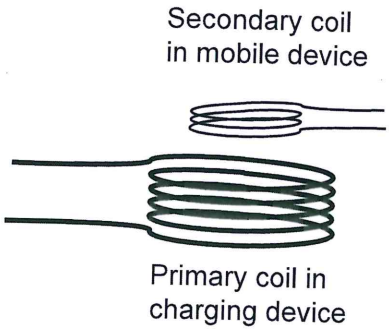
Explain, using an appropriate formula, why high-voltage power lines are used when transporting electrical power over large distances.

Description	Marks
Power lost is equal to I^2R	1
And $P = VI$	1
Therefore increasing V decreases I, reducing power lost **or** lower current means less voltage drop across the power lines due to $V = I R$	1
Total	**3**

Exam Answers
Chapter 5.3 - Transformers
Answer 6 2013:1:11

(6 marks)

Inductive charging is becoming more popular for mobile devices such as phones. A simplified diagram of the charging system is shown below.



(a) Assume that one such charging system runs directly from the mains power (240 V AC) to charge a device that requires an input of 4 V. Describe the transformer and the relationship between the two coils. (3 marks)

Description	Marks
This will be a step down transformer	1
Ratios are Vs/Vp=Ns/Np=4 V:240 V	1
so the turn ratio will be 1:60	1
Total	**3**

Note: Allow full marks for inverse or decimal turn ratio answer, but only if the appropriate ratio is indicated.

(b) Use appropriate formulae or relationships to explain how this inductive charging system works. (3 marks)

Description	Marks
A changing magnetic flux is generated in the primary coil.	1
This cuts the secondary coil	1
Induced emf = $-N\Delta BA/t$	1
Total	**3**