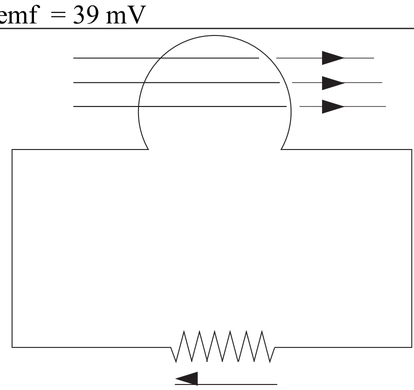
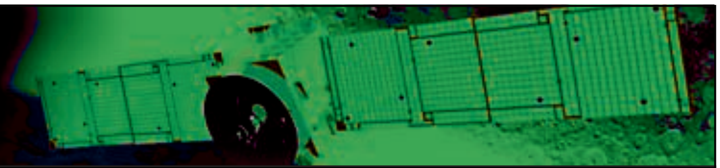
Electricity and Magnetism: Set 7

Set	Problem	Solution
7	1	v = 980 km h^{-1} = 272.2 m s^{-1} emf = l v B = 60 m × 272.2 m s^{-1} × 3.5 × 10^{-5} T emf = 0.57 V
	2a	P = I V If the transformer is only 90% efficient then 50 W = 0.9 × I V 50 W = 0.9 × 240 V × I I = 2.3 A
	2b	Heat energy produced by the transformer may affect the functioning of the other electronic components in the TV, the vents allow the heat energy to escape.
	3	When the magnet is moved into the coil, the approaching magnetic field of the magnetic north pole induced a current in the coil. When the magnet was withdrawn it again induced a current, but in the opposite direction.
	4a	The magnetic field produced by the current flowing through the primary coil induces a current in the secondary circuit. The current only flows for a short time because it is only induced while the field around the primary coil is changing (reaching its maximum value).
	4b	Increase the current in the primary circuit. Increase the number of coils in the primary coil.
	4c	In the opposite direction to the current in the primary circuit.
	5a	60 km h^{-1} = 16.67 m s^{-1} Emf = l v B = 0.5 m × 16.67 m s^{-1} × 2.5 × 10^{-5} T = 0.21 mV
	5b	Rate of flux change = B A A = 16.67 m s^{-1} × 0.5 m^2 in 1 second Rate of flux change = 2.5 × 10^{-5} T ×16.67 m s^{-1} × 0.5 m^2 = 2.1 x 10^{-4} Wb s^{-1}
	5c	The Earth's magnetic field lines run North-South, travelling south would mean travelling along field lines, not crossing them, so no emf would be induced.
	6	If the opposite of Lenz's Law was true the induced current would produce a magnetic flux in the same direction as the magnetic flux that induced the current. This increased magnetic flux would produce a larger current which in turn would produce a greater magnetic flux and so on. This process would continue to produce an indefinite current in the motor and burn the motors out (and break the law of the conservation of energy).
	7	$\phi = BA = 0.5\ T \times \pi \times (1.5 \times 10^{-2})^2 = 3.53 \times 10^{-4}$ Wb $emf = -N\frac{\Delta\phi}{t} = 200 \times \frac{3.53 \times 10^{-4} Wb}{10 s}$ emf = 7.1 mV
	8a	$emf = -N\frac{\Delta\phi}{t} = 1 \times \frac{0.25\ T \times \pi \times (0.1 m)^2}{0.2 s}$ emf = 39 mV
	8b & 8c	
	8d	V = I R I = V/R = 3.9 × 10^{-2} V / 5Ω = 7.9 mA



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Set	Problem	Solution
7	9a	$v = 80\ \text{km h}^{-1} = 22.2\ \text{m s}^{-1}$ $\text{emf} = l\,v\,B = 1.0\ \text{m} \times 22.2\ \text{m s}^{-1} \times 3.6 \times 10^{-5}\ \text{T} = 8.0 \times 10^{-4}\ \text{V}$
	9b	For the vertical component directed up out of the ground the electrons in each axle will experience a force which will move them towards the end of the axle facing towards the south east.
	10	As the aluminium plate passes through the magnetic field an emf is induced in the plate. The induced current produces a magnetic field which opposes the external magnetic field. This causes the plate to slow down as it falls through the field. As the plate leaves the field the direction of the induced current changes and so does the magnetic field it produces. This also causes the plate to slow down, but as it leaves the field. This damping effect causes the plate to come to a stop more quickly than if the magnetic field was absent.
	11	50 Hz = 50 cycles in 1 second. ¼ cycle takes 5.0×10^{-3} s $N = \frac{emf \times t}{\Delta\phi} = \frac{180\ V \times 5.0 \times 10^{-3} s}{0.2\ T \times 2 \times 10^{-2} m^2}$=225 turns
	12a	emf = l v B $v = \frac{emf}{l \times B} = \frac{10 \times 10^{-3} A \times 2.5\ \Omega}{20 \times 10^{-3}\ m \times 0.5\ T} = 2.5\ \text{m s}^{-1}$
	12b	$F = I\,l\,B = 10 \times 10^{-3}\text{A} \times 20 \times 10^{-3}\text{m} \times 0.5\ \text{T}$ $F = 1.0 \times 10^{-4}\ \text{N}$
	13a	For 60 Hz, ¼ cycle takes 0.004 s, area of coil = $(200 \times 10^{-3}\text{m})^2 = 0.04\ \text{m}^2$ $B = \frac{emf \times t}{N \times A} = \frac{240\ V \times 0.004\ s}{300 \times 0.04\ m^2}$ B =83 mT
	13b	The maximum emf is produced when the coil is parallel to the field, ¼ of the way through the cycle. Zero voltage is produced ½ way through the cycle when the coil is perpendicular to the field.