Electrical Fundamentals

Set 15: Electrical Energy and Power

15.1	(a)	$I = \frac{P}{V} = \frac{1200\ W}{240\ V} = 5.0\ A$
	(b)	$R = \frac{V}{I} = \frac{240\ V}{5\ A} = 48.0\ \Omega$
15.2	(a)	$V = \frac{P}{I} = \frac{6\ W}{0.5\ A} = 12.0\ V$
	(b)	$R = \frac{V}{I} = \frac{12\ V}{0.5\ A} = 24.0\ \Omega$
15.3		$R = \frac{V^2}{P} = \frac{(240\ V)^2}{100\ W} = 576\ \Omega$
15.4	(a)	E = V x I x t = 12 V x 2 A x (20 min x 60 s) = 28.8 kJ
	(b)	P = I x V = 2 A x 12 V = 24.0 W
	(c)	q = I x t = 2 A x (20 min x 60 s) = 2.4 x 10^3 C
15.5	(a)	It is designed to run from a power supply of voltage, $V = \frac{P}{I} = \frac{4\ W}{0.017\ A} = 235\ V$ since household mains electricity has an RMS value of about 240 V, then it must be a household lamp since car batteries only deliver 12 V.
	(b)	$R = \frac{P}{I^2} = \frac{4\ W}{(0.017\ A)^2} = 13.8\ k\Omega$
15.6	(a)	It is designed to run from a power supply of voltage, $V = \frac{P}{I} = \frac{2.3\ W}{0.38\ A} = 6.1\ V$ This is typical of a battery or maybe a transformer.
	(b)	$R = \frac{P}{I^2} = \frac{2.3\ W}{(0.38\ A)^2} = 15.9\ \Omega$
15.7	(a)	$I = \frac{P}{V} = \frac{55\ W}{12\ V} = 4.6\ A$
	(b)	$R = \frac{V}{I} = \frac{12\ V}{4.6\ A} = 2.6\ \Omega$
15.8	(a)	E (in kWh) = P (in kW) x t (in h) = 0.060 kW x (9 weeks x 5 days x 3 h) = 8.1 kWh so the cost = 8.1 kWh x 13c kWh^{-1} = 105c (or $1.05)
	(b)	E (in kWh) = P (in kW) x t (in h) = 0.011 kW x (9 weeks x 5 days x 4 h) = 1.49 kWh so the cost = 1.49 kWh x 13c kWh^{-1} = 19c
	(c)	E (in kWh) = P (in kW) x t (in h) = 2.4kW x 4h = 9.6 kWh

		so the cost = 9.6 kWh x 13c kWh^{-1} = 125c (or \$1.25)
	(d)	E (in kWh) = P (in kW) x t (in h) = 1.7 kW x $\left(\frac{5\text{ min}}{60\text{ min h}^{-1}}\right)$ = 0.14 kWh so the cost = 0.14 kWh x 13c kWh^{-1} = 1.8c
15.9	(a)	E (in kWh) = P (in kW) x t (in h) = 2kW x 3h = 6 kWh so the cost = 6 kWh x 13c kWh^{-1} = 78c
	(b)	$P = \frac{V^2}{R} = \frac{(240\text{ V})^2}{26\,\Omega} = 2215\text{ W or }2.22\text{ kW}$ E (in kW h) = P (in kW) x t (in hrs) = 2.22kW x 4hrs = 8.88 kW h so the cost = 8.88 kW h x 13c kWh^{-1} = 115c (or \$1.15)
	(c)	P = I x V = 8 A x 240 V = 1920 W E (in kWh) = P (in kW) x t (in h) = 1.92 kW x $\left(\frac{30\text{ min}}{60\text{ min h}^{-1}}\right)$ = 0.96 kWh so the cost = 0.96 kWh x 13c kWh^{-1} = 12.5c
15.10		For a house which has 18 ceiling lights @ 100 W each and 12 table lamps @ 75 W each, the total power = (18 x 100 W) + (12 x 75 W) = 2700 W (2.7 kW) During autumn / winter they could all be on for 6 h each evening, so t = (6 months x 30 days x 6 h) = 1080 h During spring / summer they may only all be on for 2 h each evening, so t = (6 months x 30 days x 2 h) = 360 h E (in kWh) = P (in kW) x t (in h) = 2.7kW x (1080 h + 360 h) = 3888 kWh so the cost = 3888 kW h x 13c kWh^{-1} = 50500c (about \$500)
15.11	(a)	$I = \frac{P}{V} = \frac{150\text{ W}}{240\text{ V}} = 0.625\text{ A or }625\text{ mA}$
	(b)	$R = \frac{V}{I} = \frac{240\text{ V}}{0.625\text{ A}} = 384\,\Omega$
	(c)	total energy produced each hour, E = P x t = 150 W x (1 h x 3600s) = 240 kJ light energy produced each hour = 5% of 240 kJ = 0.05 x 240 kJ = 27 kJ
	(d)	E = P x t = 0.15 kW x 5 h = 0.75 kWh so the cost = 0.75 kW h x 13c kWh^{-1} = 9.8c
15.12	(a)	Energy saving each hot day, E = P x t = 4 kW x 3 h = 12 kWh which is equivalent to a monetary saving of = 12 kWh x 13c kWh^{-1} = 156c (or \$1.56) so the number of hot days to recoup the \$800 insulation cost = $\frac{\$800}{\$1.56\text{ day}^{-1}} = 513\text{ days}$
	(b)	In Australia, we probably have 3 months (about 90 hot days) each year when we use our air

		conditioners. So, the cost of the insulation should be covered in $\frac{513\text{ days}}{90\text{ days year}^{-1}} = 5.7\text{ years}$
15.13	(a)	E = V x I x t = 12V x 1A x (40 h x 3600 s) = 1.73 MJ (using a combination of 1 A for 40 hours)
	(b)	E = V x I x t = 12V x 1A x (75 h x 3600 s) = 3.24 MJ (using a combination of 1 A for 75 hours) time to operate 2 emergency lights, $t = \frac{E}{P} = \frac{3.24 \times 10^6\text{ J}}{2 \times 55\text{ W}} = 2.95 \times 10^4\text{ s or } 8.2\text{ h}$
15.14		E = V x I x t = 1.4V x 1A x (2.3 h x 3600 s) = 11.6 kJ (using a combination of 1 A for 2.3 hours) time to operate a 'key light', $t = \frac{E}{P} = \frac{11.6 \times 10^3\text{ J}}{3\text{ W}} = 3.87 \times 10^3\text{ s or } 64.5\text{ min}$