Heating & Cooling

Set 10: Heat, Temperature and Thermal Energy

10.1	(a)	the Sun
	(b)	electric current (rapidly moving free electrons)
	(c)	frictional forces created by moving parts
10.2		$\text{Efficiency} = \frac{\text{useful output energy}}{\text{total input energy}} = \frac{215\text{ J}}{985\text{ J}} \times 100\% = 21.8\%$
10.3		The engine's coolant takes the heat away from the engine and then attempts to lose this heat energy to the atmosphere. On a cool day, there is a bigger temperature difference between the engine and the surrounding air so the rate of heat flow will be greater – heat will flow away more effectively, meaning the engine will remain that bit cooler.
10.4	(a)	energy lost = 45 J – 18 J = 27 J $\% \text{ of energy lost} = \frac{27\text{ J}}{45\text{ J}} \times 100\% = 60\%$
	(b)	Drop the squash ball from a measured height and measure the height of the rebound. Since height is directly proportional to potential energy and potential energy lost is equal to the kinetic energy gained (ignoring air resistance), then $\frac{\text{height of rebound}}{\text{height of drop}}$ should confirm the squash ball's inefficiency. Repeat several times from a range of heights. Measuring the temperature of the ball before and then after several rallies would also confirm that the ball itself is acquiring heat energy from somewhere.
	(c)	It is transferred to the surrounding air as heat and sound, with the ball itself getting warmer due to absorbing some of the "lost" energy.
10.5	(a)	Heat energy (and some sound energy).
	(b)	The immediate surroundings acquire this energy – the brake pads, the car tyres, the road surface and the air.
10.6		The freezer would continually lose cold air into the room, so it would have to work harder. In doing so, it would actually transfer more heat energy from the fins at the rear of the freezer to the surrounding air effectively making the room warmer.
10.7		Most electric heaters create heat directly, using elements which heat up when an electric current passes through them. These 'direct element' heaters include portable heaters, panel convectors and off-peak storage heaters. They have a maximum efficiency of 100%, when all the electricity is converted to heat and delivered to the room. Reverse cycle air conditioning extracts heat from the outside air, even on mid-winter nights, and transfers it inside. A refrigerant is passed through an external coil, absorbing heat from the outside air. This refrigerant is then pumped through a compressor into a fan coil unit (or 'condenser') inside the home, releasing its heat into the room. Up to three or more units of heat can be transferred for every unit of electricity used to run reverse cycle air conditioning. Therefore, running costs can be as low as one-third of those for direct element heaters. By reversing the flow of this refrigerant, reverse cycle air conditioners also provide efficient refrigerative cooling in summer.

10.8	(a)	Low grade energy is often a wasted or non-useful form of energy or energy that cannot be easily used.
	(b)	High grade energy is the kind of energy you want to obtain from a machine or transducer and it is often the purpose for using the particular device – it is a useful energy form.
	(c)	High grade energy would include the electrical energy produced by a power station or the kinetic energy produced by the engines of motor vehicles (via the chemical energy stored in its fuel).
10.9	(a)	Use a feedback system to put the thermal energy back into the power station in order to heat the offices, or the hot water system, or even back into the electricity making process aspect of the station itself.
	(b)	Australian working environments tend to require cooling systems, rather than heating systems.
10.10	(a)	High temperatures mean the particles will have much greater kinetic energy so the resultant effect will make a greater amount of mechanical energy available to the engine.
	(b)	In cold weather there is a greater temperature difference between the heat engine and the surrounding air. Heat flows more easily (quickly) under such circumstances.
10.11		Electrical energy produced each day = power x time = 1000 MW x (24 h x 3600 s h^{-1}) = 8.64×10^{13} J Since the power station is only 50% efficient, it needs twice this amount of input energy from the coal it burns each day Required input energy each day = 1.728×10^{14} J $\text{Mass of coal required per day} = \frac{\text{energy needed each day}}{\text{energy provided per kilogram}} = \frac{1.728 \times 10^{14}\ \text{J}}{25 \times 10^{6}\ \text{J kg}^{-1}} = 6.91 \times 10^{6}\ \text{kg}$ (or 6912 tonnes).