Environmental Sciences
Physics coursework

1. What are the SI units for: time, mass, temperature and force?
(4 marks)

The SI unit for time is second (s), for mass it is kilogram (kg), for temperature it is kelvin (K), and for force it is newton (N or kg*m*s^{-2}).

2. a) A car travels at 54 km per hour, what is its speed in meters per second?
(2 marks)

Given: speed = 54 km/hr

Converting this to meters per second (m/s):

$$(54\ \cancel{km}/\cancel{hr})(1000\ m/\cancel{km})(\cancel{1\ hr}/60\ \cancel{min})(\cancel{1\ min}/60\ s)$$

$$= (54)(1000)/(60)(60)\ m/s$$

$$54\ km/hr\ \mathbf{= 15\ m/s}$$

b) If the car is initially at 54 km per hour and accelerates at a constant rate, reaching a final speed of 90 km per hour after 15 seconds, what is the value of this acceleration, expressed in ms^{-2}.
(3 marks)

Given: $speed_i$ = 54 km/hr = 15 m/s
$speed_f$ = 90 km/hr
time = 15 s

Since the initial speed ($speed_i$) was already converted in the previous item, the final speed ($speed_f$ = 90 km/hr) needs to be converted to m/s.

$$speed_f = (90\ \cancel{km}/\cancel{hr})(1000\ m/\cancel{km})(\cancel{1\ hr}/60\ \cancel{min})(\cancel{1\ min}/60\ s)$$

$$= (90)(1000)/(60)(60)\ m/s$$

$$speed_f = 25\ m/s$$

Now to get the acceleration (a):

$$a = (speed_f - speed_i)/time$$

$$= (25\ m/s - 15\ m/s)/15\ s$$

$$\mathbf{a = 0.67\ m/s^2}$$

c) A car is initially at 16.2 km per hour and travels at this velocity for 30 seconds; it then accelerates to 45 km per hour in 25 seconds and stays at this velocity for 45 seconds. What is the total distance covered by the car in 100 seconds described?
(5 marks)

Given: $speed_1$ = 16.2 km/hr

$t_1 = 30$ s
$speed_2 = 45$ km/hr
$t_2 = 25$ s
$t_3 = 45$ s

First, speeds 1 and 2 need to be converted to m/s for easier calculations:

$$speed_1 = (16.2\ \cancel{km}/\cancel{hr})(1000\ m/\cancel{km})(\cancel{1\ hr}/60\ \cancel{min})(\cancel{1\ min}/60\ s)$$

$$= (16.2)(1000)/(60)(60)\ m/s$$

$$speed_1 = 4.5\ m/s$$

$$speed_2 = (45\ \cancel{km}/\cancel{hr})(1000\ m/\cancel{km})(\cancel{1\ hr}/60\ \cancel{min})(\cancel{1\ min}/60\ s)$$

$$= (45)(1000)/(60)(60)\ m/s$$

$$speed_2 = 12.5\ m/s$$

Next, the distance (d_a) travelled as it accelerates from speed 1 to 2 is calculated:

$$d_a = (1/2)(speed_1 + speed_2)(t_2)$$

$$= (1/2)(17\ m/s)(25\ s)$$

$$= 212.5\ m$$

Lastly, to get the total distance, we add this to the distance travelled while at constant $speed_1$ and distance travelled while at constant $speed_2$.

$$\text{Total distance} = d_a + speed_1 t_1 + speed_2 t_3$$

$$= 212.5\ m + (4.5\ m/s)(30\ s) + (12.5\ m/s)(45\ s)$$

$$= 212.5\ m + 135\ m + 562.5\ m$$

total distance = 910 m

3. A 2.5 kg box is initially at rest when a horizontal force of 15 N is applied. What is the velocity of the box after the force has been continually applied for half a minute? (3 marks)

Given: $m = 2.5$ kg
$v_i = 0$ m/s
$F = 15$ N
$t = 30$ s
$v_f = ?$

Force can be solved for using:

$$F = m(v_f - v_i)/\ t$$

Thus, with the given values, the final velocity (v_f) can be solved for by:

$$v_f = v_i + Ft/m$$

$$= 0\ m/s + (15\ \cancel{kg}m/s^{\cancel{2}})(30\ \cancel{s})/(2.5\ \cancel{kg})$$

$$= (15)(30)/(2.5)\ m/s$$

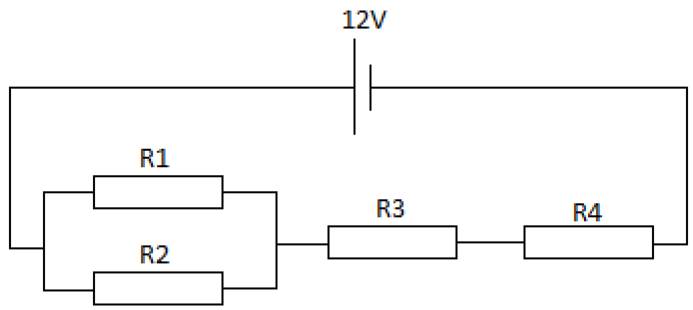
$$\mathbf{v_f = 180\ m/s}$$

4. Explain why it is easier to keep an object in motion than to start an object to moving?

(4 marks)

This phenomenon is best explained by Newton's first law, or the law of inertia. The law states that: "In the absence of a net force, the center of mass of a body either is at rest or moves at a constant velocity." In other words, an object that is at rest will stay at rest unless acted upon by an unbalanced force, and an object in motion will stay in motion unless acted upon by an unbalanced force. An object that is already in motion is already in its inertial state, in the absence of any other forces acting on it like friction that would slow it down or make it stop, it will simply continue that way with no effort on your or anyone's behalf. To make an object start moving, on the other hand, is taking an object away from its inertial state, which is at rest. This is where the exertion of force comes in. So of course it is easier to keep an object in motion because all you need to do is leave it alone, than to start an object moving because you need to exert force on it.

5. Analyze the circuit below



a) What is the effective total resistance of the network shown? Take the following as the resistor values: R1 = 3 Ω, R2 = 2 Ω, R3 = 4.3 Ω, R4 = 1 Ω.
(3 marks)

Total Resistance (R_{eff}) is calculated using the following equation:

$$R_{eff} = (R1R2)/(R2 + R1) + R3 + R4$$

$$= (6\ \Omega)/(2\ \Omega + 3\ \Omega) + 4.3\ \Omega + 1\ \Omega$$

$$\mathbf{R_{eff} = 6.5\ \Omega}$$

b) What is the current drawn from the power supply, if the resistors have the following values: R1 = R2 = R3 = R4 = 2 Ω?
(4 marks)

First, we get the effective resistance using the equation from the previous item:

$$R_{eff} = (R1R2)/(R2 + R1) + R3 + R4$$

$$= (4\ \Omega)/(2\ \Omega + 2\ \Omega) + 2\ \Omega + 2\ \Omega$$

$$R_{eff} = 5\ \Omega$$

From the diagram, the voltage (V) = 12 V, knowing Reff, the current (I) is calculated using:

$$V = IR_{eff}$$

$$I = V/R_{eff}$$

$= 12\ V/5\ \Omega$

$\mathbf{I = 2.4\ A}$

6. Apart from the liquid increasing in volume, give an example of a property that changes with temperature and can be used as a basis for a thermometer?
(2 marks)

Air or vapour pressure also increases and decreases in direct proportion to the rise and fall of temperature. This can also be used as a basis for a thermometer by keeping the volume of the container of the gas constant and attaching something that can act as a barometer to the pressure-based thermometer.

7. 600 g of water is in a kettle at 15 degrees C. How much energy is required to produce 50 g of steam? Assume the heat capacity of the kettle is 1 J C^{-1}, the specific heat capacity of water is 4186 J kg^{-1} C^{-1} and the latent heat of vaporization is $2.26 \cdot 10^6$ J kg^{-1}. The kettle and water remain in thermal equilibrium, and no heat loss is to the surroundings.
(7 marks)

Given: $m_w = 600$ g
$T_i = 15\ ^oC$
$H_k = 1$ J/C
$c_w = 4186$ J/kgC
$L = 2.26 \times 10^6$ J/kg

First, the amount of energy (Q_1) needed to raise the temperatures of the kettle and water to $T_f = 100$ C, to reach boiling point:

$$Q_1 = (mc_w)(T_f - T_i) + (H_k)(T_f - T_i)$$

$$= (mc_w + H_k)(T_f - T_i)$$

$$= [(0.6\cancel{kg})(4186\ J/\cancel{kgC}) + (1\ J/\cancel{C})](100\ \cancel{C} - 15\ \cancel{C})$$

$$= (2512.6)(85)\ J$$

$$Q_1 = 213,\ 571\ J$$

Next, the amount of energy (Q_2) needed to produce $m_s = 50$ g of steam from the water:

$$Q_2 = m_sL$$

$$= (0.05\ \cancel{kg})(2.26 \times 10^6\ J/\cancel{kg})$$

$$= 113,\ 000\ J$$

The total amount of energy needed (Q_{tot}) is obtained by simply adding both energies:

$$Q_{tot} = Q_1 + Q_2$$

$$= 213,\ 571\ J + 113,\ 000\ J$$

$$\mathbf{Q_{tot} = 326,\ 571\ J\ or\ 3.27 \times 10^5\ J}$$