Mixed Exercise – 1 (Year 13)

1.

(a) Fig. 2.1 shows the London Eye.

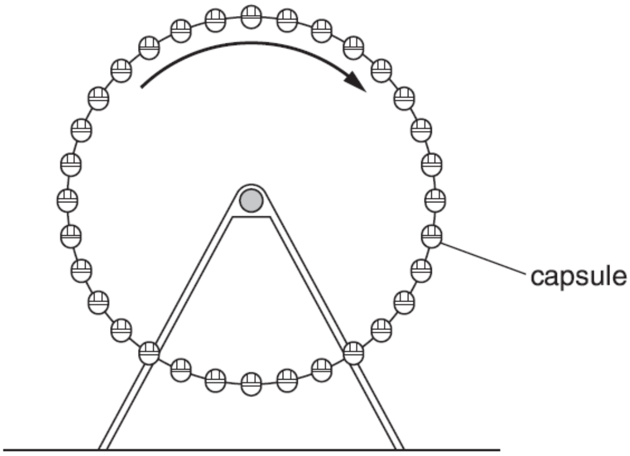

Fig. 2.1

It has 32 capsules equally spaced around the edge of a large vertical wheel of radius 60 m. The wheel rotates about a horizontal axis such that each capsule has a constant speed of 0.26 m s^{-1}.

(i) Calculate the time taken for the wheel to make one complete rotation.

time = ... s **[1]**

(ii) Each capsule has a mass of 9.7×10^3 kg. Calculate the centripetal force which must act on the capsule to make it rotate with the wheel.

centripetal force = ... N **[2]**

(b) Fig. 2.2 shows the drum of a spin-dryer as it rotates. A dry sock **S** is shown on the inside surface of the side of the rotating drum.

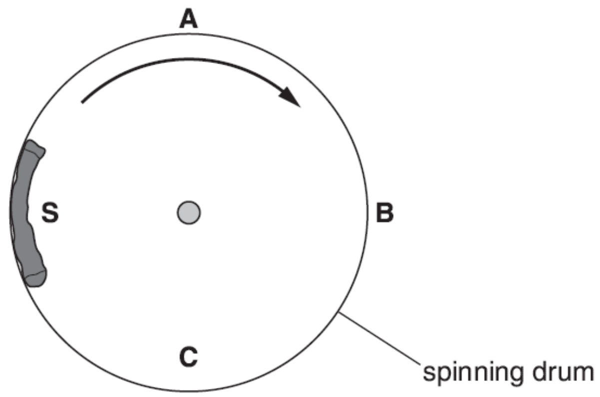

Fig. 2.2

(i) Draw arrows on Fig. 2.2 to show the direction of the centripetal force acting on **S** when it is at points **A**, **B** and **C**. **[1]**

(ii) State and explain at which position, **A**, **B** or **C** the normal contact force between the sock and the drum will be

1 the greatest

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....

....

.... **[2]**

2 the least.

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.... **[1]**

2.

(a) Fig. 3.1 shows a car of mass 800 kg travelling at a constant speed of 15 m s^{-1} around a bend on a level road following a curve of radius 30 m.

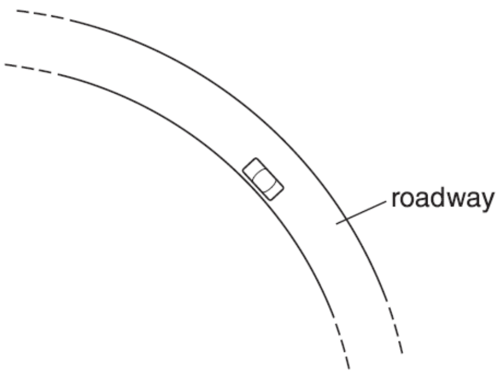

Fig. 3.1

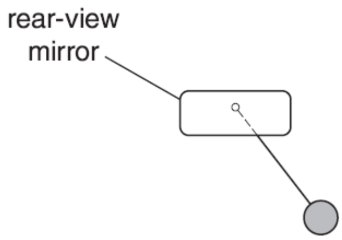

Fig. 3.2

(i) Draw an arrow on Fig. 3.1 to indicate the direction of the resultant horizontal force on the car at the position shown. **[1]**

(ii) Calculate the magnitude *F* of this force.

F = ... N **[3]**

(iii) A medallion hangs on a string from the shaft of the rear view mirror in the car.

Fig. 3.2 shows its position in the vertical plane, perpendicular to the direction of travel in Fig. 3.1.

1 Draw and label arrows on Fig. 3.2 to indicate the forces acting on the medallion. **[2]**

2 On another occasion the car travels around the bend at 25 m s^{-1}. The angle of the string to the vertical is different. Explain how and why this is so. You may find it useful to sketch a vector diagram to aid your explanation.

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.... **[3]**

(b) Each wheel assembly of the car is mounted on a suspension spring. In a garage test, one wheel assembly is suspended off the ground by its spring with the damper disconnected. Fig. 3.3 shows a graph of the vertical motion of the wheel assembly against time when it is given a small displacement and released.

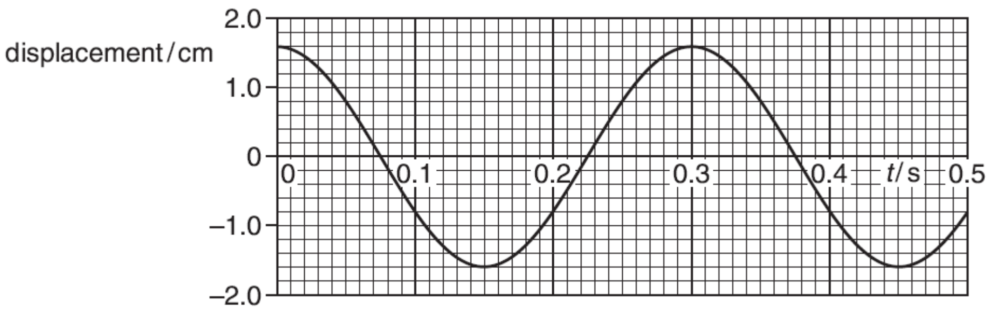

Fig. 3.3

(i) Use the graph to find the natural frequency f_0 of oscillation of the wheel.

f_0 = ... Hz **[2]**

(ii) When the car is travelling along a ridged concrete road at a speed of $20\,\mathrm{m\,s^{-1}}$ the driver notices that the car bounces significantly. The ridges in the road are equally spaced 6.2 m apart.

1 Calculate the frequency f of the bounce.

f = ... Hz **[1]**

2 State and explain the phenomenon which is occurring.

....

....

....

....

.... **[3]**

3.

(a) The ideal gas equation may be written as

$$pV = nRT.$$

State the meaning of the terms n and T.

n ....

T .... **[2]**

(b) Fig. 6.1 shows a cylinder that contains a fixed amount of an ideal gas. The cylinder is fitted with a piston that moves freely. The gas is at a temperature of 20 °C and the initial volume is $1.2 \times 10^{-4}\,m^3$. Fig. 6.2 shows the cylinder after the gas has been heated to a temperature of 90 °C under constant pressure.

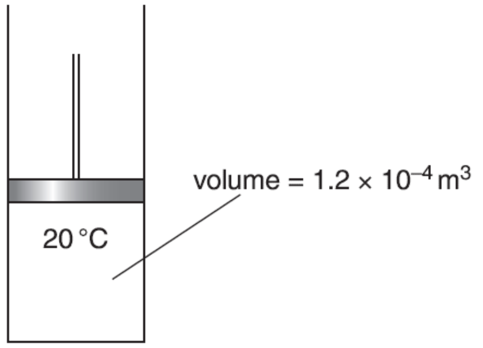

Fig. 6.1

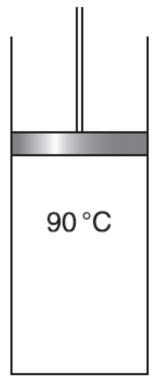

Fig. 6.2

(i) Explain in terms of the motion of the molecules of the gas why the volume of the gas must increase if the pressure is to remain constant as the gas is heated.

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.... **[4]**

(ii) Calculate the volume of the gas at 90 °C.

volume = ... m^3 **[2]**

(c) The mass of each gas molecule is 4.7×10^{-26} kg. Estimate the average speed of the gas molecules at 90 °C.

speed = ... $m\,s^{-1}$ **[3]**

4.

A gas, which is to be treated as ideal, is trapped in a cylinder by a piston, which is free to move. See Fig. 2.1.

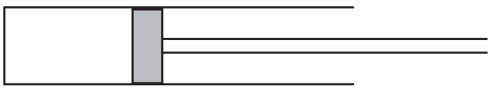

Fig. 2.1

(a) The equation of state of an ideal gas is $pV = nRT$.

State the meaning of each term in the equation.

....

....

....

....

.... **[2]**

(b) The gas is heated suddenly from 27 °C to 627 °C.

(i) The pressure before heating is atmospheric pressure, p_0. Show that the pressure immediately after heating is $3p_0$. Assume that the piston has not had time to move.

[2]

(ii) The gas then pushes the piston out until the pressure of the gas returns to atmospheric pressure p_0. The volume V_0 of the gas has increased to $2.5\,V_0$. Calculate the final temperature of the gas in °C.

temperature = ... °C **[3]**

(c) **(i)** The original volume V_0 of gas trapped in the cylinder is $3.0 \times 10^{-5}\,m^3$. Atmospheric pressure p_0 is 1.0×10^5 Pa. Show that the amount of gas is about 1×10^{-3} mol.

[2]

(ii) The molar mass M of the gas is $0.016\,kg\,mol^{-1}$. Calculate the mass m of gas present in the cylinder.

m = ... kg **[1]**

(iii) Calculate the increase in internal energy ΔU of the gas when it is heated suddenly as in **(b)(i)** from 27 °C to 627 °C.

Take the specific heat capacity of the gas to be $1300\,J\,kg^{-1}\,K^{-1}$.

ΔU = ... J **[2]**