11 Fig. 11.1a shows a U-tube of uniform cross-sectional area A containing liquid of density ρ. The total length of the liquid column is L.

The liquid is displaced by distance x from the equilibrium level as shown in Fig. 11.1b.

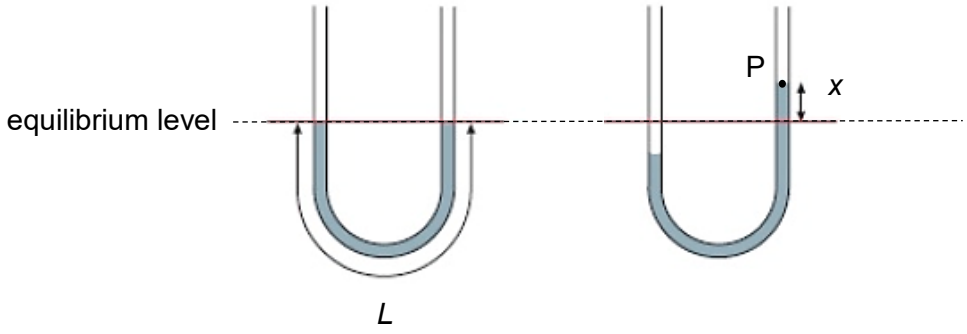

Fig. 11.1a **Fig. 11.1b**

(a) **(i)** By considering the pressure difference between the two water levels, write down an expression for the restoring force in terms of A, ρ, x and g where g is the acceleration of free fall.

[1]

(ii) Hence show that the magnitude of acceleration a of the liquid column caused by this force is

$$a = \frac{2gx}{L}$$

[2]

(iii) Use the expression in **(a)(ii)** to explain why point P on the liquid surface will move in a simple harmonic motion.

.....

.....

.....

..... [3]

(iv) The length of the liquid column L is 40.0 cm.

Determine the period of the oscillation T.

T = ... s [3]

(b) It was assumed that viscosity in the liquid is negligible. Fig. 11.2 shows the variation with time t of the displacement x.

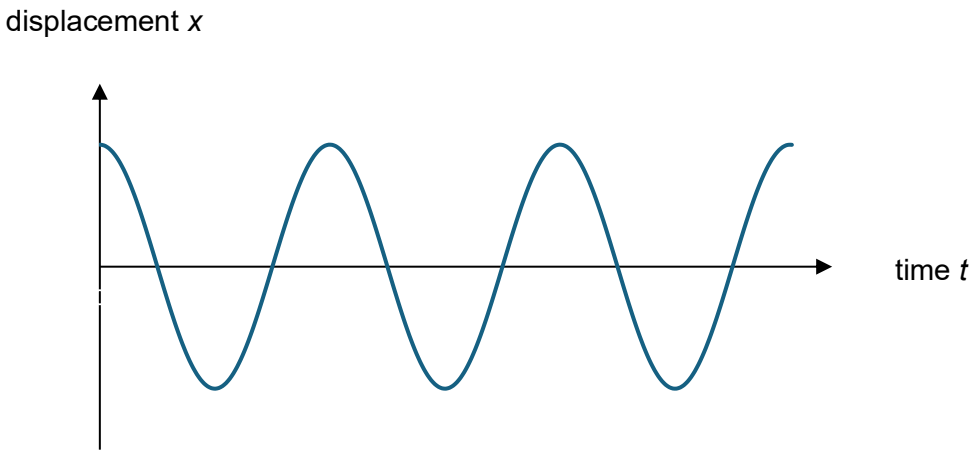

Fig. 11.2

(i) Sketch in Fig. 11.2, the variation with time t of the displacement x when viscosity of the liquid is not negligible. [2]

(ii) The mass of the liquid in the column is 500 g. The maximum displacement x is 3.5 cm. Use your answer in **(a)(iv)** to determine the maximum kinetic energy of the liquid.

maximum kinetic energy = ... J [2]

(iii) Sketch in Fig. 11.3, for the variation with displacement x of

1. the kinetic energy of the liquid. Label it E_K [2]

2. the potential energy of the liquid. Label it E_P. [1]

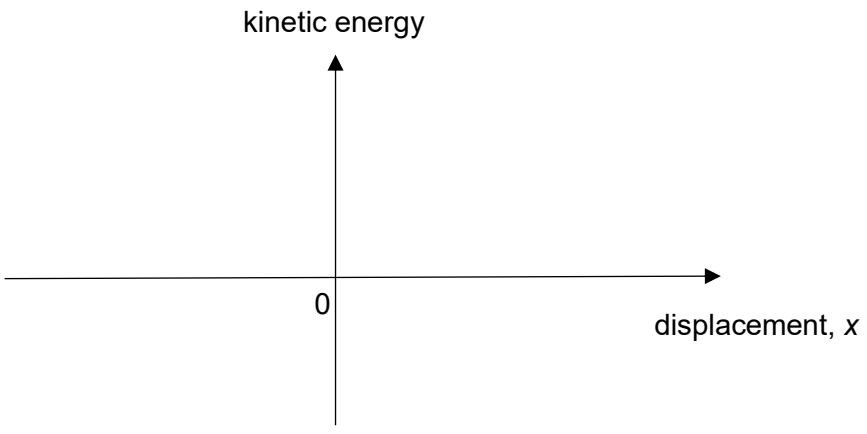

Fig. 11.3

(c) The U-tube is now placed in contact with an oscillator moving sideways as shown in Fig. 11.4. The oscillator causes the U-tube to oscillate. The frequency of oscillator can be varied.

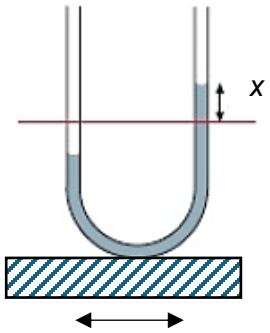

Fig. 11.4

Fig. 11.5 shows the variation with the oscillator's frequency of the amplitude of the water level.

amplitude

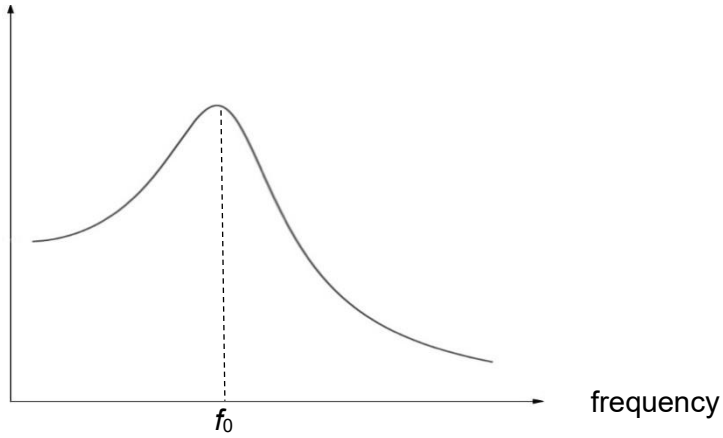

Fig. 11.5

(i) Use your answer in **(a)(iv)** to determine the value f_0.

f_0 = ... Hz [1]

(ii) Explain why there is a peak in the amplitude in Fig. 11.5.

.....

.....

.....

..... [2]

(iii) On Fig. 11.5, sketch the variation of the amplitude when the liquid in the tube is replaced by another liquid with higher viscosity. [1]

End of Paper