TUTORIAL QUESTION OSCILLATIONS

Question 1

The mass of an astronaut in an orbiting space station cannot be measured by using a normal balance. However, the mass can be measured by monitoring the oscillations of the astronaut when seated in a chair supported by a spring. The period of the oscillation T is given by the expression $T = 2\pi\sqrt{\frac{M}{k}}$ where M is the total mass of chair and astronaut, and k is the spring constant.

For a particular chair, of mass 6.3 kg, the spring to which it is attached has a spring constant of 1540 Nm^{-1}.

a.) Calculate the period of oscillation when an astronaut of mass 73.2 kg sits in the chair.

b.) Calculate the percentage change in the period of oscillation after the mass of the astronaut increased by 0.5 kg during a meal.

Question 2

An object undergo simple harmonic motion has displacement from its equilibrium position. The displacement varies with time in the way shown in Fig. 2.1 (a)

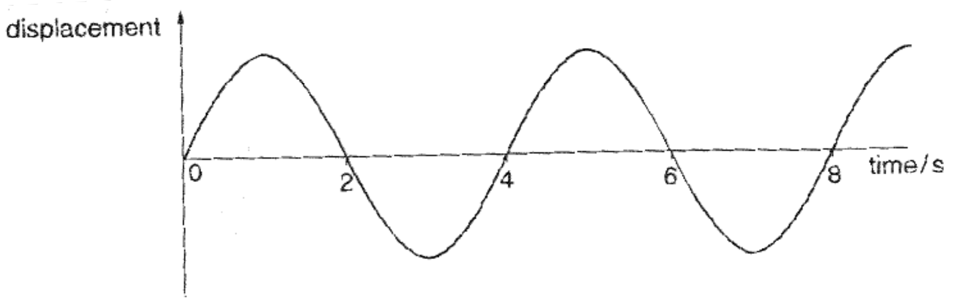

Fig. 2.1(a)

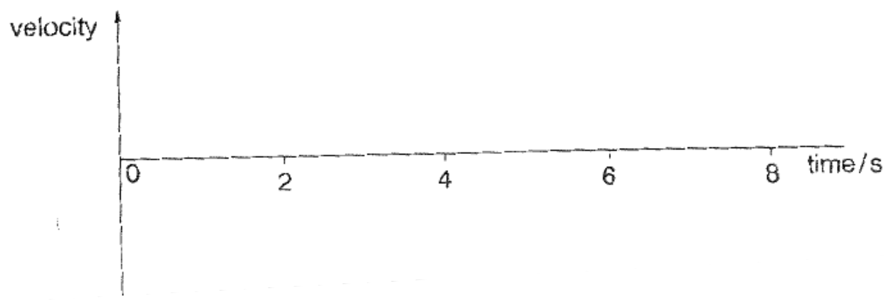

Fig. 2.1(b)

a.) On Fig. 2.1 (b), sketch the variation with time of the velocity of the object.

b.) Find the frequency,f of the oscillation.

c.) Find the angular frequency, ω of the oscillation.

d.) Find the phase difference betwee nthe displacement and the velocity.

Question 3

Fig. 3.1 below illustrates a mass whic hcan be made to vibrate vertically between two springs. The vibrator itself has a constant amplitude. As the frequency is varied, the amplitude of vibration of the mass is seen to change as shown in Fig. 3.2

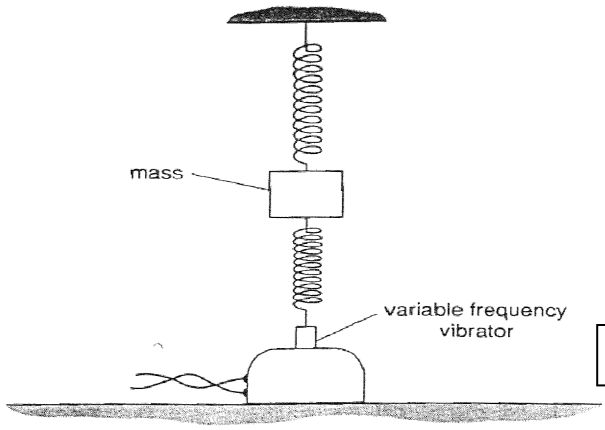

Fig. 3.1

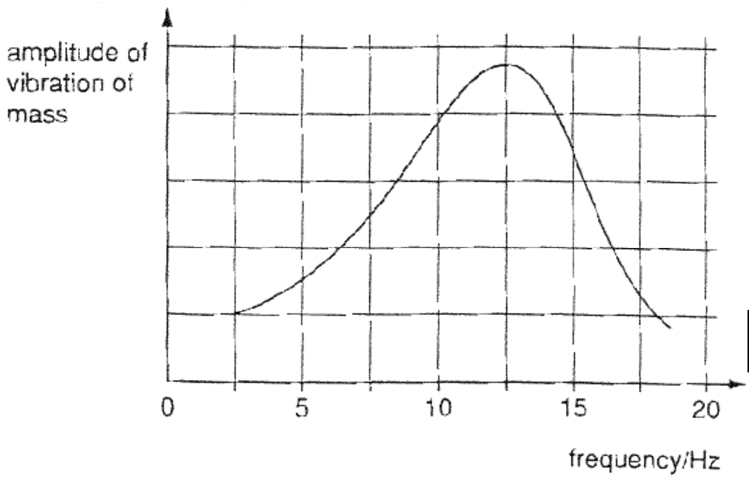

Fig. 3.2

a.) Name the phenomenon illustrated in Fig. 3.2

b.) For mass vibrating with maximum amplitude, calculate the angular frequency and period.

c.) A light piece of card is fixed to the mass with its plane horizontal. On Fig. 3.2 draw a line to show the variation with frequency of the amplitude of vibration of the mass.

d.) State one situation in which the phenomenon illustrated in Fig. 3.2 is used to advantage.

Question 4

a.) Describe an example of free oscilation. Explain why in practise a free oscillation cannot have a constant amplitude.

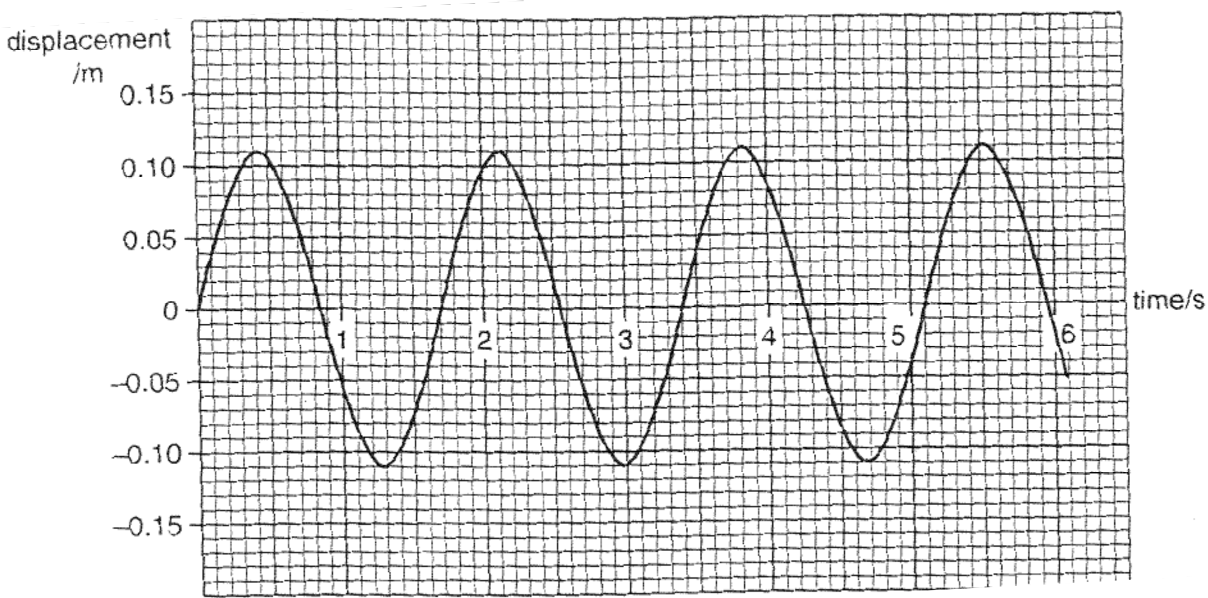

Fig. 4.1

b.) An object undergo forced oscillation has displacement y, as shown in graph of Fig. 4.1. Use the graph to determine its amplitude, period, frequency, angular frequency.

c.) Refering the graph of Fig. 4.1, state for each of the following, a time at which the oscillating object has

i.) maximum positive velocity,

ii.) maximum positive acceleration,

iii.) maximum negative acceleration,

iv.) maximum kinetic energy,

v.) maximum potential energy.

d.) A driver of constant amplitude and variable frequency f causes forced oscillations of the object. The amplitude y_0 of the object's oscillations depends on f.

i.) Sketch a graph to show how y_0 varies with f over a wide range of frequencies which includes the natural frequency fo the object.

ii.) Add to your sketch a second line which shows the effects of increased damping. Label this line D.

e.) The phenomenon which you have illustrated in (d)(i) can cause considerable engineering problems. Explain one such problem and suggest ways in which it can be overcome.

Question 5

A load of mass m is suspended form the free end of the helical spring of spring constant k as shown in Fig. 5.1. The loas is displaced vertically and then released. The load oscillates with frequency f given by the expression f = $\frac{1}{2\pi}\sqrt{\frac{k}{m}}$

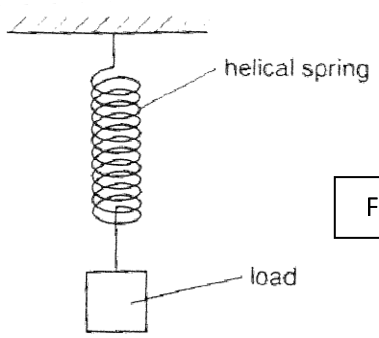

Fig. 5.1

a.) Explain what is meant by spring constant of the spring.

b.) Explain what is meant by the oscillation of the load.

c.) Motion sensors are used to monitor the movement of the load, and the variation with time t of the position of the load is as shown in Fig. 5.2

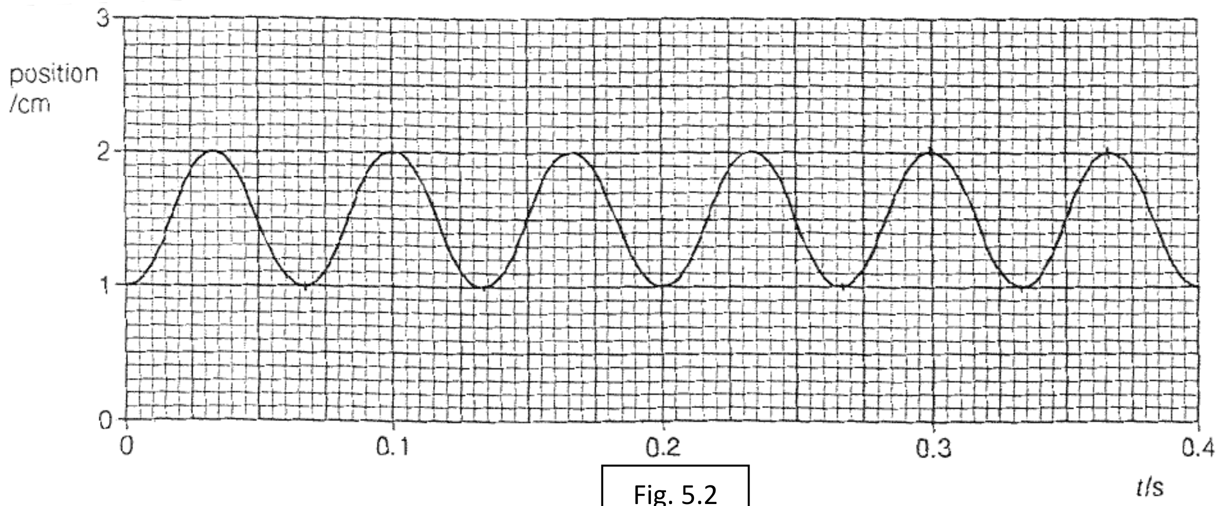

Fig. 5.2

i.) Suggest with a reason whether the motion is damped ro undamped.

ii.) Calculate the spring constant k, given that the mass of the load is 90 g.

Question 6

a.) Explain what is meant by the frequency of vibration of an object.

b.) Distinguish between the displacement of a vibrating object and the amplitude of vibration.

c.) Some sand is placed on a flat horizontal plate and the plate is made to oscillate with simple harmonic motion in a vertical direction, as illustrated in Fig. 6.1.

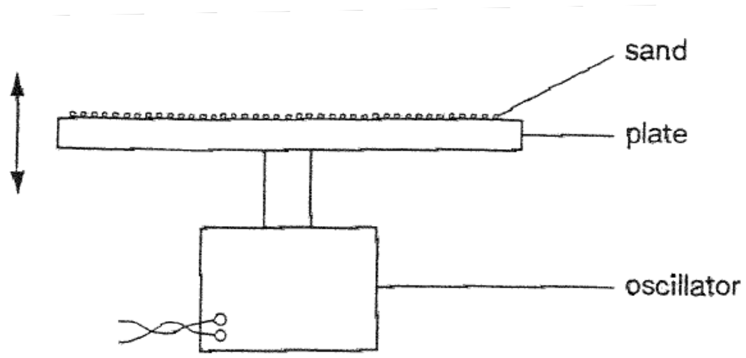

Fig. 6.1

i.) The plate oscillates with a freuqency of 13 Hz. Sketch a graph to show the variation with displacement,x of the acceleration,a of the plate.

ii.) The acceleration, a is given by the expression $a = -\omega^2 x$. Calculate the angular frequency,ω.

iii.) Calculate the amplitude of oscillation of the plate such that the maximum acceleration is numerically equal to the acceleration of free fall.

iv.) Suggest with a reason what happens to the sand on the plate when the amplitude of oscillation of the plate exceed the value calculated in (iii).

Question 7

A particle is oscillating in SHM with a period of 2 s, and an amplitude of 5 cm. What is its speed and acceleration

a.) at the centre of the oscillation,

b.) at the amplitude position,

c.) at a displacement of 2 cm?