3 A mass P is attached to the free end of a horizontal spring on a smooth surface. The spring-mass system is set into simple harmonic motion by pulling P to the right of the equilibrium position and is released from rest as shown in Fig. 3.1.

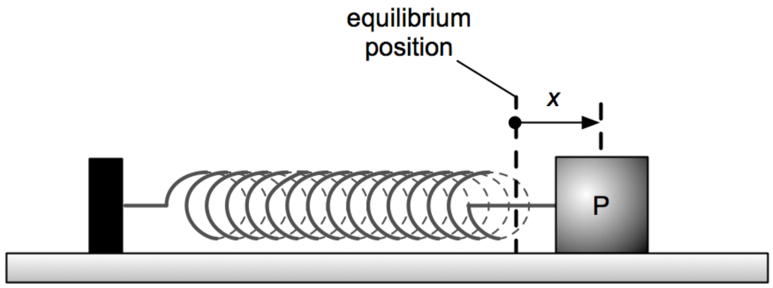

Fig. 3.1

If the air resistance on P is negligible, the variation of the velocity v of P with displacement x is shown in Fig. 3.2. Vectors to the right are taken to be positive.

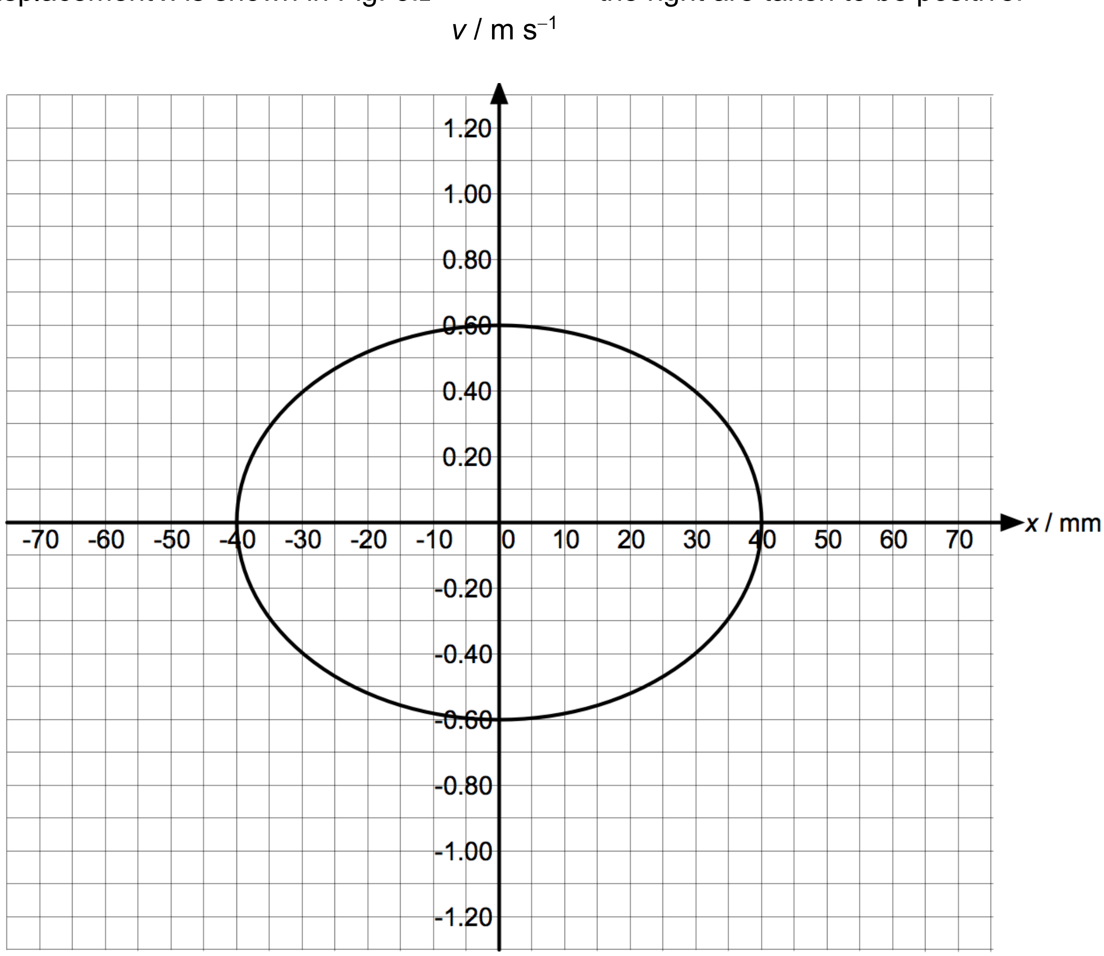

Fig. 3.2

(a) For the motion of P, determine

(i) the amplitude and

amplitude = ………………………… mm [1]

(ii) the frequency.

frequency = ………………………… Hz [2]

(b) If the air resistance on P is not negligible, sketch on Fig. 3.2 the variation of the velocity of P with displacement *x*. Label it "air resistance". [3]

(c) A periodic force is now exerted on the spring-mass system. When the periodic force is at a certain frequency, P is in resonance.

(i) Given that the total energy of the spring-mass system at steady state is doubled.

Determine the new maximum speed of P.

maximum speed of P = ………………………… m s^{-1} [2]

(ii) On Fig. 3.2, sketch the variation of the velocity of P, at resonance, with displacement *x*. Label it "resonance".

[2]