3 A peg is fixed to the rim of a vertical turntable of radius *r* rotating with a constant angular speed ω, as shown in Fig. 3.1.
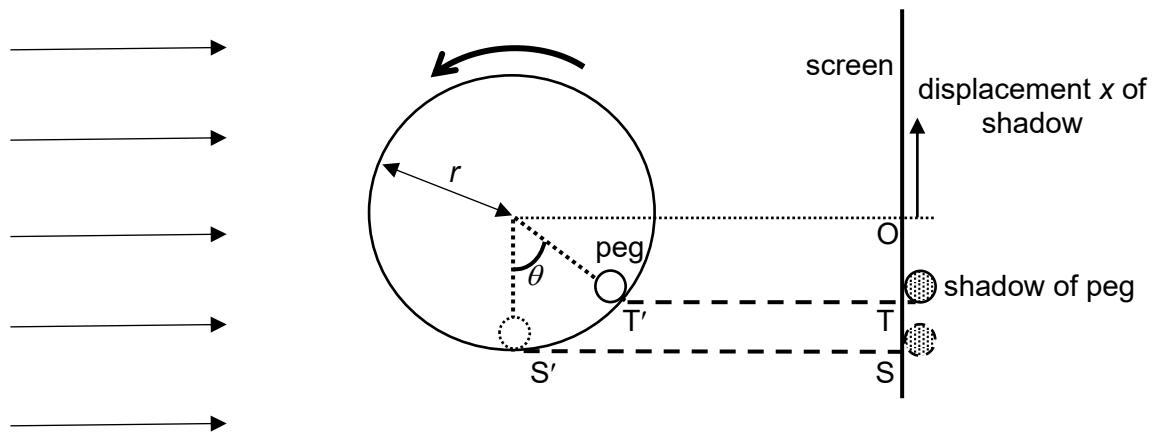

Fig. 3.1

A parallel beam of light is incident on the turntable such that the shadow of the peg is observed on the screen. Initially, the peg is at position S′ and its shadow is at S. After time *t*, the peg moves through an angle of θ and it is positioned at T′ while its shadow is at T.

The displacement *x* of the shadow from O is shown in Fig. 3.1 where the upward direction is taken to be positive.

(a) (i) Express the angular displacement θ of the peg in terms of ω and *t*.

[1]

(ii) Write down an expression for the displacement *x* of the shadow on the screen in terms of ω, *t* and *r* .

[1]

(iii) Hence, prove that the shadow of the peg is moving in simple harmonic motion. Explain your working.

[2]

(b) The turntable has a radius of 20.0 cm and angular speed of 3.5 rad s^{-1}. For the motion of the shadow on the screen,
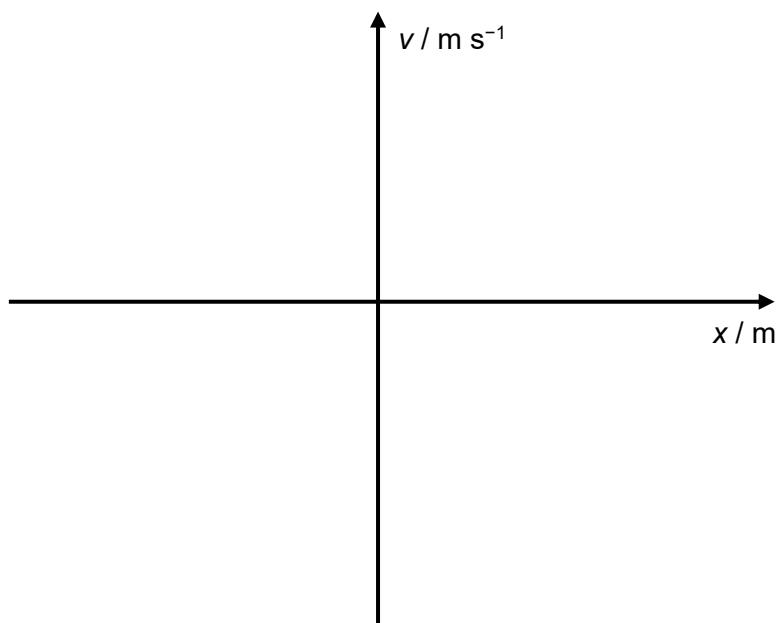
(i) calculate the acceleration of the shadow when the shadow is instantaneously at rest,

acceleration = ... m s^{-2} [1]

(ii) determine the velocity of the shadow as it passes through O,

velocity = ... m s^{-1} [1]

(iii) sketch the variation with displacement x of the velocity v of the shadow.

v / m s^{-1}

x / m

[2]