2022 Oscillation Tutorial Suggested Solutions to Self-Review Questions

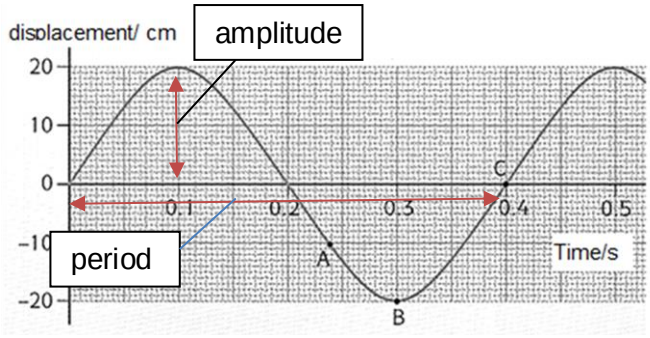
S1 **C**. The defining equation of SHM is $a = -\omega^2 x$.
Hence we can see that to obtain the a-t graph from the x-t graph, we need to 'flip' the graph about the horizontal axis.

OR

For SHM, we can deduce from the x-t graph, $x = -x_0 cos\omega t$
Hence $a = -\omega^2 x = \omega^2 x_0 cos\omega t$

S2 The general solution of SHM is $x = x_0 sin\omega t$.
Comparing the given equation with the general form, $x = 30sin50t$, we can deduce that the SHM has an amplitude of $x_0 = 30$ and angular frequency $\omega = 50$
Since $\omega = 2\pi f \Rightarrow$ f = 50 / 2π = 7.958 = 8.0 Hz

S3 (i)
(a) amplitude, x_0 = 20.0 cm
(b) period, T = 0.4000 s
(c) frequency = 1/T = 2.500 Hz
(d) angular frequency, $\omega = 2\pi f = 2\pi(2.500)$
$= 5.000\pi = 15.7$ rad s^{-1}
(e) displacement at A, x_A = -10.0 cm



(ii) x = 20.0 sin (15.7 t)
(iii) At x = -10.0 cm,

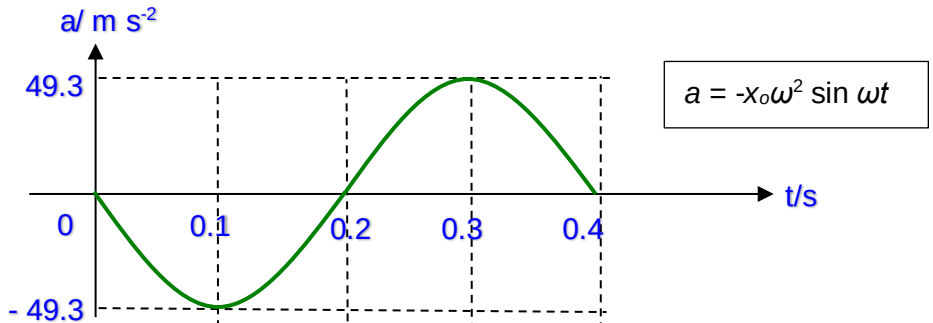
$$-10.0 = 20.0 \sin 5.000\pi t$$
$$5.000\pi t = \sin^{-1}(-0.500) = \pi + \pi/6$$
$$t = 0.233 \text{ s}$$

The value t = 0.233 s tallies reasonably well with the value from the graph (t = 0.238 s).

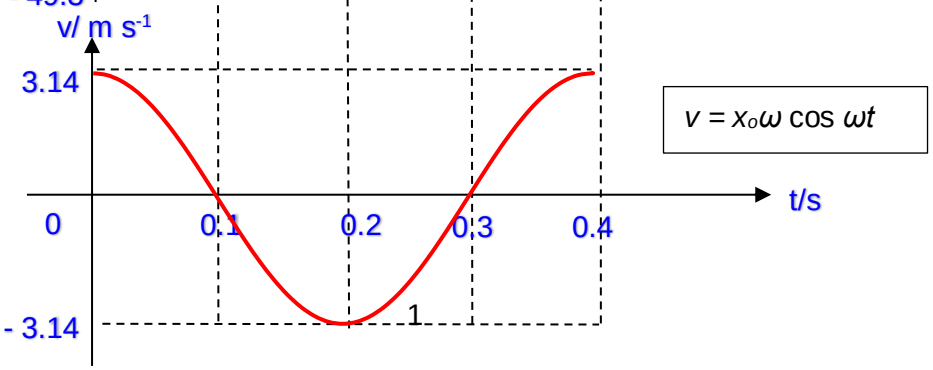
(iv) (a) velocity is maximum at C, as deduced from the gradient of the displacement-time graph.
(b) acceleration is maximum at B, since B is at maximum negative displacement.
(c) At C, maximum velocity is positive and at B maximum acceleration is positive.

(v)
(a) velocity at B, $v_B = 0$ (the gradient of the curve at B is zero)
(b) velocity at C, $v_C = \omega x_0 = 5.000\pi(0.200) = 3.14$ m s^{-1}
(c) acceleration at B, $a_B = -\omega^2(-x_0) = \omega^2 x_0 = (5.000\pi)^2(0.200) = 49.3$ m s^{-2}
(d) acceleration at C, $a_C = -\omega^2(0) = 0$

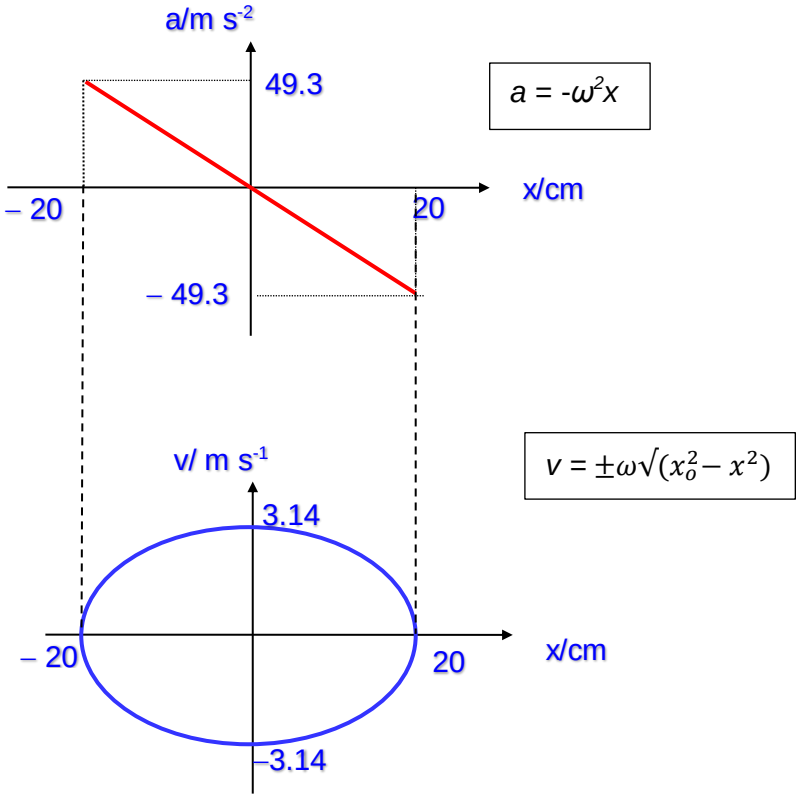
(vi) (a)



(b)



(c) & (d)



S4 $\omega = 2\pi f = 2\pi(2.0) = 4.0\pi = 12.6$ rad s^{-1}

$v_{max} = \omega x_0 = 4.0\pi(0.0080) = 0.10$ m s^{-1}, at equilibrium position

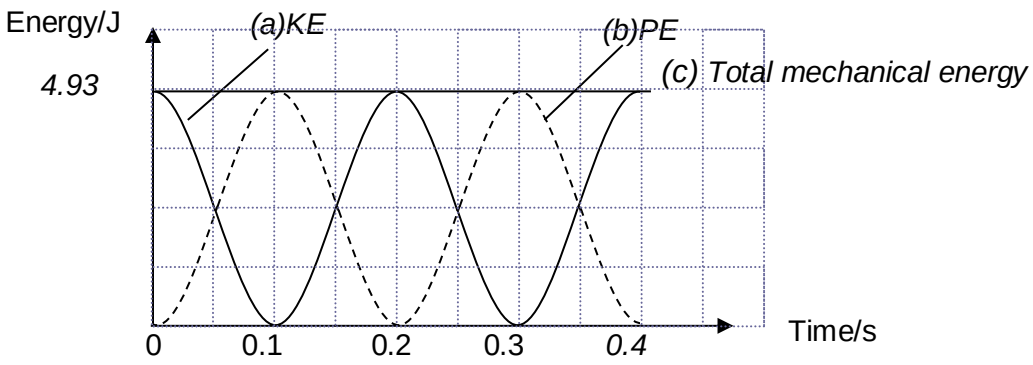
$a_{max} = \omega^2(x_0) = (4.0\pi)^2(0.0080) = 1.3$ m s^{-2} (the magnitude of acceleration at the extreme positions)

S5 (i) (a) Point B
(b) Point C

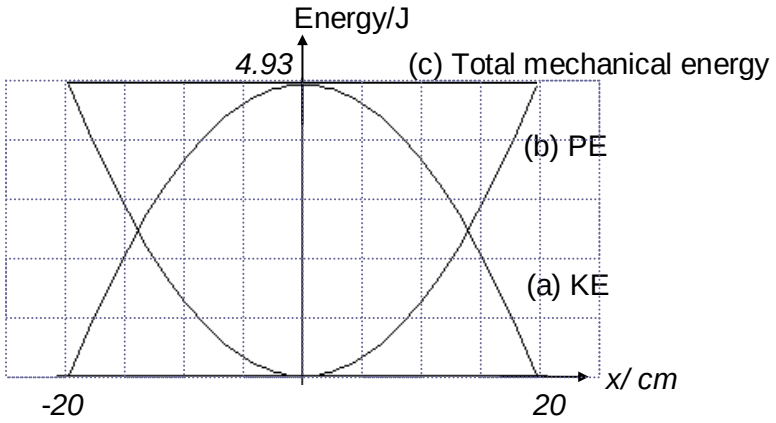
(ii) **At C**, x = 0
PE = ½ $m\omega^2x^2$ = 0 J
KE = KE_{max} = ½ mv^2_{max} = ½ (1.0)(3.14)^2 = 4.93 J

At B, $x = x_0$
PE = KE_{max} = 4.93 J
KE = 0 J

(iii)



(iv)



S6 **C**. Total energy = ½ $m\omega^2x_0^2$ = 0.5 m $(2\pi f)^2$ A^2

S7 **A**. Recognise from the F-r graph that the motion is simple harmonic. Hence the potential energy expression is a quadratic equation with minimum potential energy at the equilibrium position.

S8 **A** The amplitude *a* increases until *f* matches the resonance (natural) frequency of the pendulum, after which the amplitude *a* decreases again.

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