20 Marking scheme: Worksheet (A2)

1 **a** The period of an oscillator is the time for one complete oscillation. [1]

b The frequency of an oscillator is the number of oscillations completed per unit time (or per second). [1]

2 **a** The gradient of a displacement against time graph is equal to velocity. [1]

The magnitude of the velocity (speed) is a maximum at 0 s or 0.4 s or 0.8 s. [1]

b For s.h.m., acceleration $\propto$ −displacement.

The magnitude of the acceleration is maximum when the displacement is equal to the amplitude of the motion. [1]

The magnitude of the acceleration is a maximum at 0.2 s or 0.6 s or 1.0 s. [1]

3 **a** $T = \dfrac{13.2}{12}$ [1]

$T = 1.1$ s [1]

b $f = \dfrac{1}{T} = \dfrac{1}{1.1}$ [1]

$f = 0.909 \approx 0.91$ Hz [1]

4 **a** Amplitude = 0.10 m [1]

b Period = 4.0×10^{-2} s [1]

c $f = \dfrac{1}{T} = \dfrac{1}{0.04}$ [1]

$f = 25$ Hz [1]

d $\omega = 2\pi f = 2\pi \times 25$ [1]

$\omega = 157$ rad s^{-1} ≈ 160 rad s^{-1} [1]

e Maximum speed = $\omega A = 157 \times 0.10$ [1]

maximum speed = 15.7 m s^{-1} $\approx$ 16 m s^{-1} [1]

5 **a** Phase difference = $2\pi \times \left(\dfrac{t}{T}\right)$

where T is the period and t is the time lag between the motions of the two objects.

phase difference = $2\pi \times \left(\dfrac{t}{T}\right) = 2\pi \times \left(\dfrac{2.5}{10}\right)$ [1]

phase difference = $\dfrac{\pi}{2} \approx 1.6$ rad [1]

b Phase difference = $2\pi \times \left(\dfrac{t}{T}\right) = 2\pi \times \left(\dfrac{5.0}{10}\right)$ [1]

phase difference = $\pi \approx 3.1$ rad [1]

6 **a** $A = 16$ cm [1]

b $\omega = 2\pi f = \dfrac{2\pi}{T} = \dfrac{2\pi}{2.8}$ [1]

$\omega = 2.24$ rads^{-1} ≈ 2.2 rads^{-1} [1]

c $a = (2\pi f)^2 x$ (magnitude only) [1]

For maximum acceleration, the displacement x must be 16 cm.

$a = \left(2\pi \times \dfrac{1}{2.8}\right)^2 \times 16 \times 10^{-2}$ [1]

$a = 0.806$ m s^{-2} ≈ 0.81 m s^{-2} [1]

d Maximum speed = $\omega A = 2.24 \times 0.16$ [1]

maximum speed = 0.358 m s^{-1} $\approx$ 0.36 m s^{-1} [1]

7 a $\omega = 2\pi f = \dfrac{2\pi}{T} = \dfrac{2\pi}{2.0}$ [1]

$\omega = 3.14 \text{ rad s}^{-1} \approx 3.1 \text{ rad s}^{-1}$ [1]

b $a = -(2\pi f)^2 x$ or $a = -\omega^2 x$ [1]

$a = 3.14^2 \times 3.0 \times 10^{-2}$ [1]

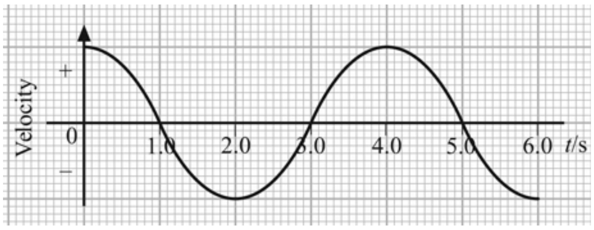
$a \approx 0.30 \text{ m s}^{-2}$ [1]

c $x = A \cos (2\pi ft) = A \cos (\omega t)$ [1]

$x = 3.0 \times 10^{-2} \cos (3.14 \times 6.7)$ [1]

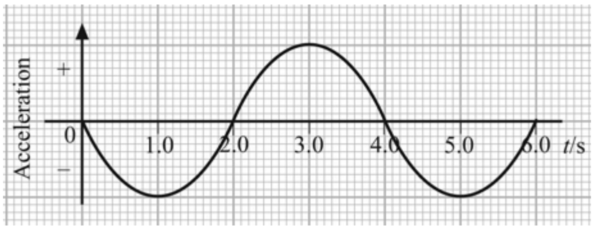
$x \approx -1.7 \times 10^{-2}$ m [1]

8 a Gradient of x–t graph = velocity



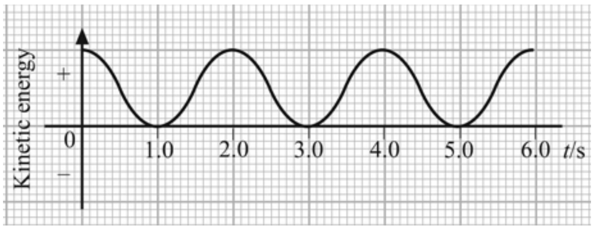
[2]

b Gradient of v–t graph = acceleration
(for s.h.m. acceleration $\propto$ –displacement)



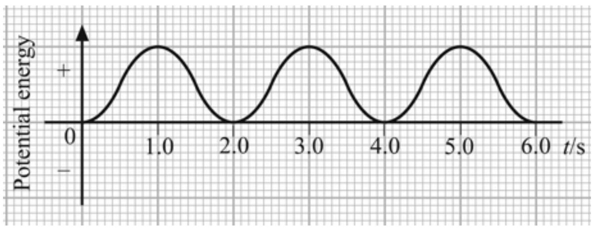
[2]

c Kinetic energy = $\dfrac{1}{2}mv^2 \propto v^2$



[2]

d Potential energy = total energy – kinetic energy



[2]

9 a $a = -(2\pi f)^2 x$ [1]

Therefore $(2\pi f)^2 = 6.4 \times 10^5$ [1]

$f = \dfrac{\sqrt{6.4 \times 10^5}}{2\pi} = 127\ \text{Hz} \approx 130\ \text{Hz}$ [1]

b $F = ma$

Acceleration is maximum at maximum displacement, so magnitude of maximum force is given by:

$F = ma = 0.700 \times (6.4 \times 10^5 \times 0.08)$ [1]

$F = 3.58 \times 10^4\ \text{N} \approx 3.6 \times 10^4\ \text{N}$ [1]

10 a According to Hooke's law, $F = -kx$ [1]

(The minus sign shows that the force is directed towards the equilibrium position.)

From Newton's second law: $F = ma$ [1]

Equating, we have: $ma = -kx$ [1]

Hence: $a = -\left(\dfrac{k}{m}\right)x$

b For s.h.m. we have $a = -(2\pi f)^2 x$ [1]

Hence $(2\pi f)^2 = \dfrac{k}{m}$ [1]

Therefore $f = \dfrac{1}{2\pi}\sqrt{\dfrac{k}{m}}$

c $f = \dfrac{1}{T} = \dfrac{1}{0.4} = 2.5\ \text{Hz}$ [1]

$2.5 = \dfrac{1}{2\pi}\sqrt{\dfrac{k}{850}}$ [1]

$k = (2\pi \times 2.5)^2 \times 850 \approx 2.1 \times 10^5\ \text{N m}^{-1}$ [1]