# Solutions for Topic 4 – Oscillations and waves

1. a) (i) point at minima of curve (acceleration maximum when displacement is minimum)

   (ii) either point of intercept with time axis (maximum speed at zero displacement)

   b) weight of the bob is opposed by the component of tension along the vertical axis i.e. $T\sin\theta = mg$

2. a) displacement graph shifted by $-\dfrac{\pi}{2}$

   b) velocity graph is the gradient of the displacement graph; velocity is maximum when displacement is zero

3. a) magnitude of acceleration is proportional to the displacement from a fixed point; direction of acceleration is towards that fixed point

   b) (i) $A = 0.5 \times d$

   (ii) and (iii)
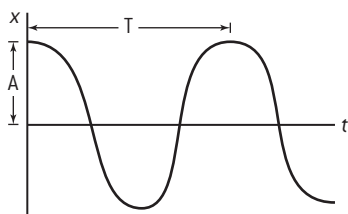
4. a) a wave in which the positions of maximum and minimum amplitude travel through the medium

   b) 4.0 mm; 2.4 cm; 3.3 Hz; 7.9 cm s^{-1}

5. a) transverse: direction of energy transfer perpendicular to direction of travel
      longitudinal: direction of energy transfer parallel to direction of travel

   b) frequency = (time for one period)$^{-1}$ = $(0.135)^{-1}$ = 7.4 Hz;
      amplitude = maximum displacement = 8 mm

   c) $c = f\lambda$; $\lambda = \dfrac{0.15}{7.4} = 0.020$ m = 2.0 cm

   d)
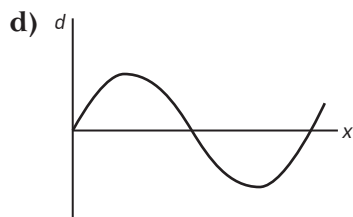
6. a) (i) ray: line showing direction in which wave transfers energy;

   (ii) wave speed is the distance wave has travelled per unit time; wave energy is the sum of the kinetic energy (maximum when speed is maximum) and potential energy (maximum when speed is zero)

   b) (i) $f = \dfrac{1}{6 \times 10^{-3}} = 167$ Hz

   (ii) at t = 1.0 ms, x_A = 1.7 mm, x_B = 0.7 mm, so total displacement = 1.7 + 0.7 = 2.4 mm

   at t = 8.0 ms; x_A = 1.7 mm; x_B = $-$ 0.7 mm, so total displacement = 1.7 $-$ 0.7 = 1.0 mm

7. a) transverse: direction of energy transfer perpendicular to direction of travel

   b) (i) frequency is 1 ÷ time period (time between successive crests) = 1 ÷ 0.13 = 7.7 Hz

   (ii) amplitude is maximum displacement = 8 mm

   longitudinal: direction of energy transfer parallel to direction of travel

   c) $c = f\lambda$; $\lambda = \dfrac{0.12}{7.7} = 0.016$ m = 1.6 cm

d)

e) $\theta = \sin^{-1}\dfrac{12}{18} = 42°$

8. a) & b)
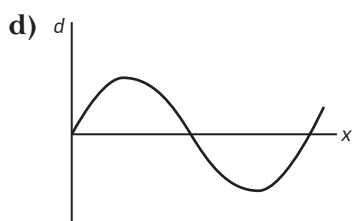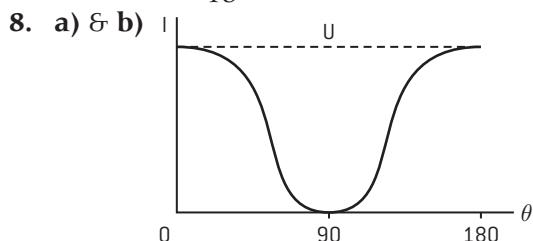
9. C; sound waves are diffracted around the headland

10. a) (i) amplitude is maximum displacement = 1.0 mm

   (ii) wavelength is distance between successive crests = 6mm

   (iii) T = 0.027 s so $f = \dfrac{1}{0.027} = 37$ Hz

   (iv) $c = f\lambda = 37 \times 0.006 = 0.22$ m s^{-1}

  b) (i) wavefront is a surface that travels with a wave; ray is a line showing direction in which wave transfers energy; rays and wavefronts are perpendicular to each other

   (ii) $1.4 \sin\theta = \sin 60$; $\theta = 38°$

   (iii) lines bent towards normal in shallower water

  c) (i) lines of minimum disturbance caused by destructive interference between two sets of waves; crest of one wave coincides with trough of another

   (ii) positions of minimum disturbance will move closer together as separation of waves decreases

11. a) standing wave has points at which displacement is always zero (nodes); there is no energy transferred by standing wave

  b) (i) sound wave is reflected at boundary, producing two waves of equal amplitude in opposite directions

   (ii) at boundary between water and air

   (iii) displacement increased so it is more than half a wavelength; moved past the first harmonic

  c) $\lambda = 2 \times 0.368 = 0.736$ m; $c = f\lambda = 440 \times 0.736 = 324$ m s^{-1}

12. a) standing wave has points at which displacement is always zero (nodes); no energy transferred by wave; maximum amplitude at harmonics

  b) (i) P at open end of pipe

   (ii) $l = \dfrac{\lambda}{4} = \dfrac{330}{4 \times 16} = 5.2$ m

  c) 1st harmonic at high frequency; to get lower sounds, need a closed pipe

13. a) maxima/minima caused by waves interfering constructively/destructively

  b) (i) 9 maxima so order = 4; $\lambda = \dfrac{130}{4.5} = 29$ mm

   (ii) $f = \dfrac{c}{\lambda} = \dfrac{3 \times 10^8}{0.029} = 10$ GHz

  c) Place two polarising filters in path of microwaves between transmitter and receiver. Rotate one filter 360, should see intensity at transmitter rise to maximum and fall to zero twice in the course of one rotation.