Solutions for Topic 9 – Wave phenomena (AHL)

1. a) acceleration is directly proportional to displacement; acceleration in opposite direction to displacement

b) $a = -\omega^2 x$

gradient of graph $= -5 \times 10^6$ so $\omega = \sqrt{5 \times 10^6} = 2236$ rad s^{-1}

frequency $= \frac{2240}{2\pi} = 350$ Hz

c) amplitude = maximum displacement = 0.60 mm

2. a) (i) maxima or minima of curve (max acceleration at max or min displacement)

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

b) SHM part of circular path; centripetal force towards centre of circle = T – mg, therefore T > mg.

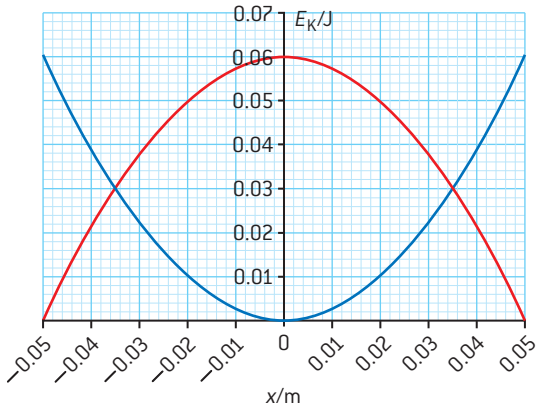
c) (i) potential energy mgh converted to kinetic energy $\frac{1}{2}mv^2$

so $v = \sqrt{2gh} = 0.70\ m$ s^{-1}

(ii) $T = \frac{mv^2}{r} + mg = 0.035 + 0.56 = 0.59$ N

3. a) restoring force $F = -kx$ (opposite direction to displacement)

b) (i)

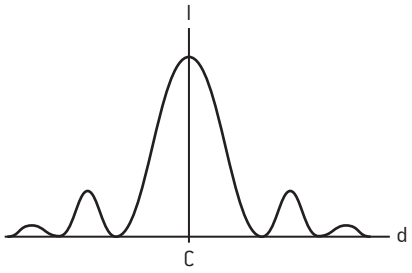


(ii) $E_K = \frac{1}{2}mv^2$ gives maximum velocity of 0.63 m s^{-1}

$v_{max} = \omega x_0$ where $x_0 = 0.05\ m$ so $f = \frac{0.63}{2\pi \times 0.05} = 2.0$ Hz

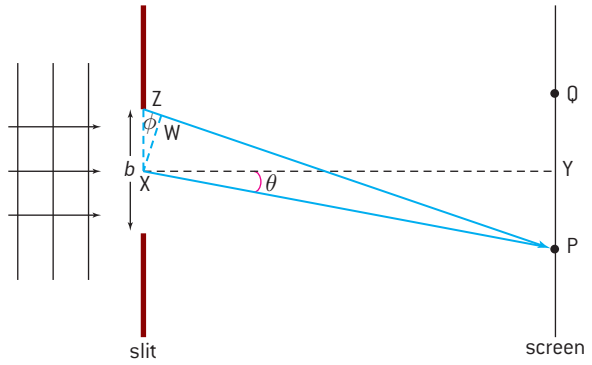
4. a) diffraction of light occurs when light passes through a narrow slit, causing waves to bend and create an interference pattern

b)



c) width $= \frac{2 \times D \times \lambda}{a} = 5.9$ mm

5. a)



b) path difference is half of a wavelength for destructive interference

c) $ZW = \frac{\lambda}{2} = \frac{b}{2}\sin\theta$; use small angle approximation and rearrange to get answer

d) angular width $\frac{2 \times 450 \times 10^{-9}}{0.15 \times 10^{-3}} = 6.0 \times 10^{-3}$ rad

6. a) waves between A and B at same intensity with same spacing as original graph

b) $\sin\theta = \frac{\lambda}{d} = \frac{450 \times 10^{-9}}{1.25 \times 10^{-6}}$ gives $\theta = 21°$

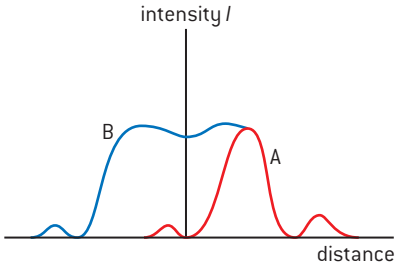
7. a) $\frac{d}{\lambda} = \frac{1}{6.0 \times 10^{5} \times 590 \times 10^{-9}} = 2.8$ so maximum order in each direction is 2, plus zero order gives 5.

b) second order peak will be **wider** and **fainter** than first order peak

8. a) **(i)** 180° or π **(ii)** 0

b) minimum thickness is $\frac{\lambda}{2} \times \frac{1}{n} = \frac{620 \times 10^{-9}}{2} \times \frac{1}{1.4} = 2.2 \times 10^{-7}\ m$

9. a) b)



c) $\theta = 1.22\frac{\lambda}{a} = 2.4 \times 10^{6}$

separation $s = \theta \times d = 2.4 \times 10^{6} \times 8.1 \times 10^{16} = 2.0 \times 10^{11}$ m

10. a) ratio of the wavelength of the light to the smallest difference in wavelength that can be resolved by the grating

b) **(i)** $\frac{2000}{0.2} = 10000$ lines mm^{-1}

(ii) $\Delta\lambda = 0.2$ nm

$\frac{\lambda}{\Delta\lambda} = 3280$ which is greater than the resolvance, so no.

11. wave speed remains the same, wavelength measured by observer is smaller as wave fronts are closer together due to approaching sound source.

12. a) f′ is higher than f due to Doppler effect; observer is walking towards source so intercepts crests of wavefront at higher rate than they are emitted

b) $f' = f\frac{v}{v - u_s}$ $3.0 \times 10^{2} \times \frac{330}{315} = 314$ Hz

13. all lines shifted to the right to slightly higher wavelengths (redshift); shift is greater at higher wavelengths