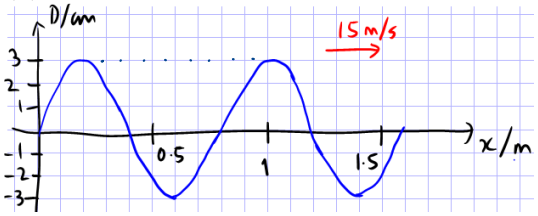
$v = f\lambda = \frac{\omega}{k}$

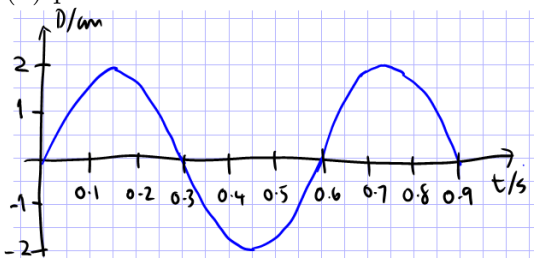
1. For the following snapshots of a wave, determine the amplitude, frequency and wavelength.
   (a) snapshot at $t = 0$ s



$A = 3\text{cm}$ $f = 15 \div 0.8 = 18.75\text{Hz}$

$\lambda = 0.8\text{m}$

   (b) particle located at $x = 1.0$ m. Wave has speed of 24 m/s to the right.



$A = 2\text{cm}$ $\lambda = \frac{24}{1.67} = 14.4\text{m}$

$f = \frac{1}{0.6} = 1.67\text{Hz}$

$A\sin(kx - \omega t)$ → travelling in the positive x

$A\sin(kx + \omega t)$ → travelling in the negative x

Ans: (a) $A = 3$ cm, f =18.75 Hz, λ =0.8 m
(b) $A = 2$ cm, f =1.67 Hz, λ =14.4 m

2. A wave is described by $y(x,t) = A\sin(kx - \omega t)$, where $A = 2.00$ cm, $k = 2.11$ rad/m, $\omega = 3.62$ rad/s. x is in metres and t is in s. (y: displacement of particle)
   (a) Determine the amplitude, wavelength, frequency and speed of the wave.
   (b) What is the displacement of a particle located at $x = 0.10$ m at a time $t = 0.60$ s?

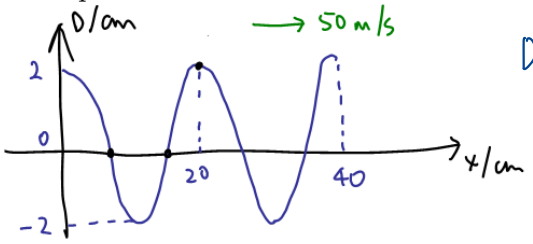
$\omega = 2\pi f$ $k = \frac{2\pi}{\lambda}$ $v = f\lambda$

Ans: (a) $A = 2$ cm, f =0.576 Hz, λ =2.98 m, $v = 1.72$ m/s (b) -1.85cm

$A = 2\text{cm}$ $f = \frac{\omega}{2\pi} = 0.576\text{Hz}$ $\lambda = \frac{2\pi}{k} = 2.98\text{m}$ $v = 1.7\text{m/s}$

$y(0.1, 0.6) = 2\sin(2.11(0.1) - 3.62(0.6)) = -1.85\text{cm}$

3. A snapshot of a wave at $t = 0$ s is shown. Write a possible equation for the wave.



$D(x,t) = 0.02\cos(31.4x - 1570t)$

$f = 50 \div 0.2 = 250$ $\omega = 2\pi f = 1570\text{rad/s}$

$k = \frac{2\pi}{0.2} = 31.4\text{rad/m}$

Ans: $D(x,t) = 0.02\cos(31.4x - 1570t)$ m

Standing wave = $2A\sin kx\cos\omega t$

4. The displacement of a standing wave on a string is given by $D(x,t) = 2.4\sin(0.60x)\cos(42t)$, where x and D are in cm and t is in s.
   (a) what is the distance between nodes? $\frac{\lambda}{2}$
   (b) What is the amplitude, frequency and speed of each of the component waves?

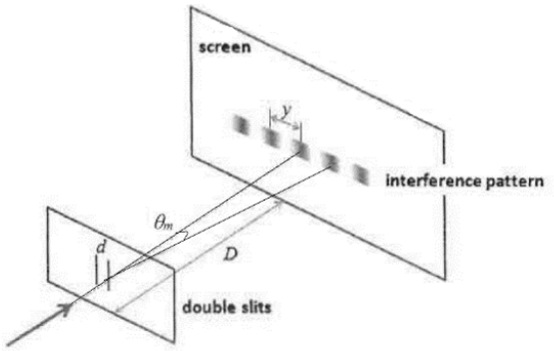
Ans: (a) 5.23cm, (b) A=1.2cm, f = 6.69Hz, v = 70 cm/s

$\frac{2\pi}{0.60} = 10.47$ $\frac{10.47}{2} = 5.23\text{cm}$

$A = \frac{2.4}{2} = 1.2\text{cm}$ $\frac{42}{2\pi} = 6.69\text{Hz}$ $v = 6.68 \times 10.47 = 70\text{cm/s}$

5. The following diagram shows a set-up of the Young's Double slit experiment. The bright spots in the interference pattern are evenly spaced out. D is the distance from the slits to the

screen, d is the distance between slits, and y is the distance between the centres of the bright spots. Identify the angle θ_m in the diagram. Hence or otherwise, using the small angle approximation and other suitable assumptions, show that the wavelength of the light $\lambda = dy/D$.



$\tan\theta = \frac{y}{D} = \sin\theta = \theta = \frac{\lambda}{d}$

$y = \frac{D\lambda}{d}$

$\lambda = \frac{dy}{D}$

$d\sin\theta = \lambda$

6. In a Young's double-slit experiment, a light source of 450 nm was passed through a pair of very narrow slits 0.08 mm apart. For a screen 1.5 m away, what is the distance between the centres of two consecutive bright spots? Use the formula you derived in previous question.

Ans: 8.437 mm

$D = L = 1.5\text{m}$, $\tan\theta = \frac{y}{D} = \sin\theta = \theta = \frac{\lambda}{d}$, $y = \frac{D\lambda}{d} = 8.4375\text{mm}$, $d\sin\theta = \lambda$

7. Two thin parallel slits that are 0.0111 mm apart are illuminated by coherent light of wavelength 585nm. On a very large distant screen, what is the total number of bright fringes that can be seen (this includes the central fringe)? *Hint:* Use the fact that $|\sin\theta| \leq 1$.

Ans: ~~39~~ 37

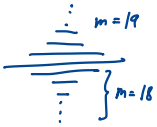
$d = 0.0111\text{mm}$, $\lambda = 585\text{nm}$

For maximum, $d\sin\theta = m\lambda$, $m = 0, \pm1, \pm2 \ldots$

$\Rightarrow \sin\theta = \frac{m\lambda}{d} \leq 1$

$m = \frac{d}{\lambda} = 18.97 \approx 19$ maximum (include central maximum)

$19 + 18 = 37$



8. Light of wavelength 633 nm falls on a pair of slits, forming fringes 3.00 mm apart on a distant screen. What would be the fringe spacing if the wavelength was 425 nm?

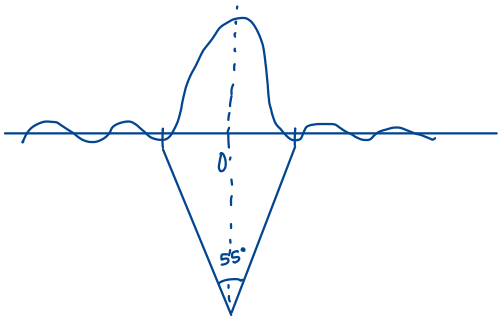
Ans: 2.01mm

$\lambda_1 = 633\text{nm}$, $y = 3\text{mm}$

$y_1 = \frac{D\lambda_1}{d}$, $y_2 = \frac{D\lambda_2}{d} = \frac{y_1}{\lambda_1} \times \lambda_2 = \frac{3\times10^{-3}}{633\times10^{-9}} \times 425\times10^{-9} =$ λ_2

9. When blue light of wavelength 440 nm falls on a single slit, the first dark bands on either side of the centre are separated by 55°. Determine the width of the slit.

Ans: 953nm



First min, when $\sin\theta = \frac{\lambda}{D}$ or $D = \frac{\lambda}{\sin\theta}$

$\theta = \frac{55}{2}° = 27.5°$

$D = \frac{440\text{nm}}{\sin 27.5°} = 953\text{nm}$