Answers to exam-style questions

Topic 9

Where appropriate, 1 ✓ = 1 mark

1 B

2 D

3 A

4 D

5 A

6 B

7 A

8 C

9 A (The question should have referred to the wavelength in air)

10 C

11 **a** In simple harmonic motion the acceleration is opposite to and proportional to the displacement from the equilibrium position. ✓
This means that a graph of acceleration against time should a straight line through the origin with a negative slope. ✓
Which is what this graph is. ✓

b **i** The amplitude is 2.6 cm. ✓

ii The gradient is $-\omega^2 = -\frac{12}{5.2\times10^{-2}} \Rightarrow \omega = 15.19 \text{ rad s}^{-1}$ ✓

$\omega = 2\pi f \Rightarrow f = \frac{15.19}{2\pi} = 2.4 \text{ Hz}$ ✓

c **i** $E_{max} = \frac{1}{2}m\omega^2 x_0^2 = \frac{1}{2}\times 0.25 \times 15.19^2 \times (2.6\times10^{-2})^2$ ✓

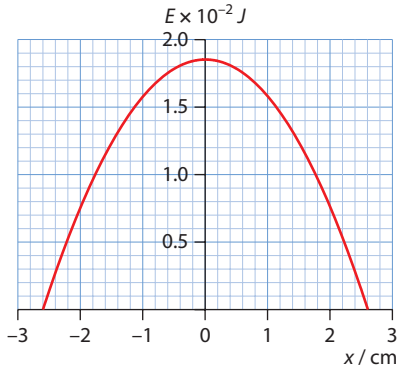
$E_{max} = 1.9479\times10^{-2} \approx 1.9\times10^{-2} \text{ J}$ ✓

ii $E_K = E_P \Rightarrow E_K = \frac{1}{2}E_{max}$ ✓

$E_K = \frac{1}{2}\times 1.9497\times10^{-2} = 9.75\times10^{-3} \text{ J}$ ✓

$\frac{1}{2}\times 0.25\times v^2 = 9.75\times10^{-3} \Rightarrow v = \sqrt{\frac{2\times9.75\times10^{-3}}{0.25}} = 0.279 \approx 0.30 \text{ m s}^{-1}$ ✓

d Correct shape of parabola. ✓
Correct intercepts. ✓



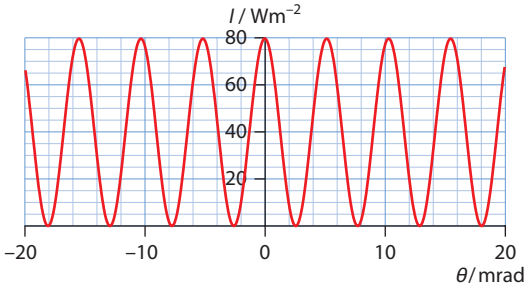
12 a i Light diffracting from each slit arrives at the screen. ✓
At those positions where the phase difference between the 2 waves is 0 the resulting amplitude is twice that of the wave from just one slit and we have bright fringes (constructive interference). ✓

ii The separation of the bright fringes is given by $s = \frac{\lambda D}{d}$ and so $\lambda = \frac{sd}{D}$. ✓

$$\lambda = \frac{1.86 \times 10^{-2} \times 0.120 \times 10^{-3}}{3.60} \checkmark$$

$$\lambda = 6.20 \times 10^{-7} \text{ m} \checkmark$$

b Correct overall shape. ✓
Correct peak intensity. ✓
Correct separation of fringes. ✓



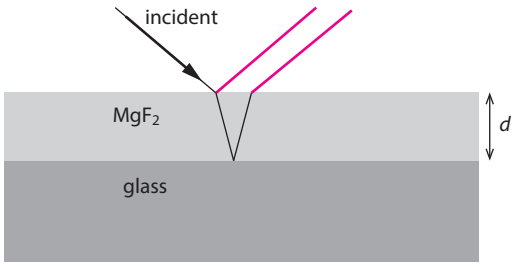
c i $d \sin\theta = n\lambda \Rightarrow d = \frac{n\lambda}{\sin\theta} = \frac{2 \times 6.2 \times 10^{-7}}{\sin 58°} = 1.462 \times 10^{-6} \text{ m} = 1.462 \times 10^{-3} \text{ mm} \checkmark$

Hence number of rulings per mm is $\frac{1}{1.462 \times 10^{-3}} = 684 \checkmark$

ii We must have that $1.462 \times 10^{-6} \times \sin 58° = n\lambda$ so that $n\lambda = 1.2398 \times 10^{-6}$ m. ✓
$n = 1$ does not lead to a visible wavelength. ✓

We cannot have $n = 2$ so we try $n = 3$ to find $\lambda = \frac{1.2398 \times 10^{-6}}{3} = 4.13 \times 10^{-7}$ m which fits the visible spectrum. ✓
No other value of n gives a visible wavelength. ✓

13 a Parallel reflected rays in red. ✓
Correct refraction of one of the rays. ✓



b At reflection point between air and magnesium fluoride. ✓
At reflection point between magnesium fluoride and glass. ✓

c At normal incidence the path difference is $2d$ and the phase difference due to reflection is zero. ✓

Hence for destructive interference $2dn = (m + \frac{1}{2})\lambda$. ✓

Giving for the least thickness ($m = 0$) $d = \frac{\lambda}{4n} = \frac{5.0 \times 10^{-7}}{4 \times 1.38} = 9.1 \times 10^{-8}$ m. ✓

14 a The number of secondary maximum is 2 less than the number of slits. ✓
And we have 2 secondary maxima. ✓

b i The secondary maxima becomes less pronounced. ✓
The primary maxima become brighter. ✓
The primary maxima become narrower. ✓

ii The separation between the primary maxima increases. ✓

c The average wavelength is $\frac{656.45 + 656.27}{2} = 656.36$ nm. ✓

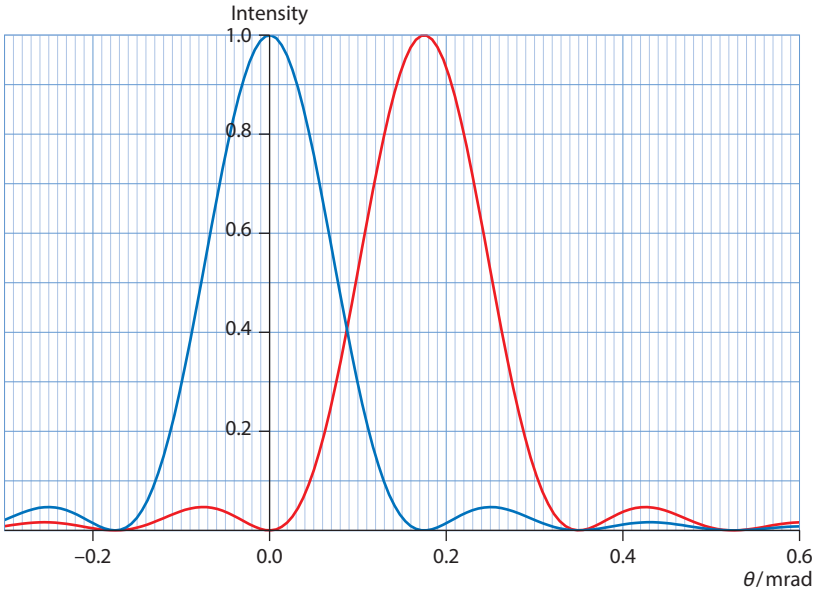
From $\frac{\lambda}{\Delta\lambda} = mN$ we have that $\frac{656.36}{656.45 - 656.27} = 2 \times N$. ✓

$N = 1823$ ✓

15 a The first minimum is at 0.175 mrad. ✓

And so from $\theta = 1.22\frac{\lambda}{b}$ we find $b = 1.22\frac{\lambda}{\theta} = 1.22 \times \frac{5.0 \times 10^{-7}}{0.175 \times 10^{-3}} = 3.49 \times 10^{-3}$ m. ✓

b i Same shape. ✓
With maximum coinciding with first minimum of the other pattern. ✓

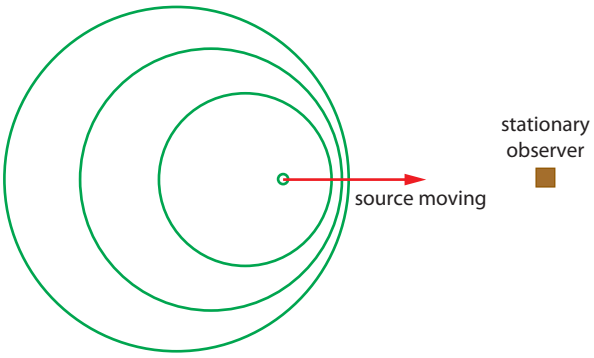


ii The angular separation of the two sources is $\frac{3.0 \times 10^{-2}}{D}$ where D is their distance from the slit. ✓

According to Rayleigh, $\frac{3.0 \times 10^{-2}}{D} = 0.175 \times 10^{-3}$ giving $D = \frac{3.0 \times 10^{-2}}{0.175 \times 10^{-3}} = 171 \approx 170$ m. ✓

16 a The change in observed frequency when there is relative motion between the source and the observer. ✓

b Circular wavefronts. ✓
Bunching in front of the source. ✓



c Ultrasound is directed at moving particles in the blood stream and the reflection is recorded. ✓
From the frequency shift it is possible to measure the speed of blood flow. ✓

d The speed of the point on the disc is $\frac{2\pi \times 0.20}{\frac{1}{8}} = 10.0\ \text{m s}^{-1}$. ✓

The frequencies received range from $\frac{340}{340+10} \times 2400\ \text{Hz} = 2331 \approx 2300\ \text{Hz}$ when source moves away from observer, ✓

to $\frac{340}{340-10} \times 2400\ \text{Hz} = 2473 \approx 2500\ \text{Hz}$ when source moves towards the observer. ✓

The wavelengths correspondingly vary from $\frac{340}{2473} = 0.137 \approx 0.14\ \text{m}$ to $\frac{340}{2331} = 0.146 \approx 0.15\ \text{m}$. ✓