Advanced Higher Physics

Wave Phenomena

Past Paper Questions

Solutions

1. (a) (i) (A) 10 Hz (B) 5.02 m

(ii) (A) 3.5 (is multiplied by 1.4) (B) $y = 4.9 \sin(62.8t - 1.25x)$

(b) 1091 Hz

2. (a) (i) $y = 0.040 \sin 2\pi\, 3.0(t + x/0.050)$
or $y = \sin 0.040 \sin 2\pi(3.0t + 60x)$

(ii) decreased by a factor of 4

(b) (constructive and destructive interference) - see notes

(c) (i) 184 Hz

(ii) away from Earth - larger wavelength means smaller frequency so source (galaxy) moving away from observer

3. (a) 25 mm

(b) 880 mms^{-1} or 0.88 ms^{-1}

(c) 3π rad or 9.42 rad

(d) e.g. 16 mm

4. (a) (i) 1.91 Hz (ii) 12.6 m

(b) (i) 0.50 rad (ii) 0.042 s

(c) e.g. $y = 6.0 \sin (12t + 0.50x)$ - note change of sign

5. (a) (i) strong (nuclear) force

(ii) (A) 2 x up, 1 x down (B) 1 x up, 2 x down

(b) weak (nuclear) force

(c) 1.13×10^{-10}m

6. (a) (i) 250 Hz (ii) $y = 4.0 \times 10^{-4} \sin (1570t + 4.6x)$

(b) (i) above 800 Hz whilst approaching, less than 800 Hz whilst receding

(ii) see notes (wavefronts compressed whilst approaching so more incident per second on observer etc)

(iii) 17.9 ms^{-1}

7. (a) $y = 0.05 \sin 2\pi (3.0t - 50x)$

   (b) $y = 0.05 \sin 2\pi (3.0t + 50x)$

   (c) $A = 0.035$ m

8. (a) (i) see notes (driver crossing wavefronts at a frequency higher than that with which they are emitted by siren)

   (ii) 1342 Hz

   (b) Moving away from Earth - wavelength longer (red shift) so source moving away according to Doppler effect

9. (a) division of amplitude

   (b) 2.76×10^{-4}m

   (c) (i) fringes get closer

   (ii) water increases optical path of light (nd) so, for same phase difference between fringes, 'd' is smaller

10. (a) (i) see notes

    (ii) need to be given 'n' for magnesium fluoride - 1.38

    thickness $= 9.1 \times 10^{-8}$ m

    (iii) surface totally non-reflecting only for one wavelength in middle of spectrum; some red and blue light reflected, mixing to give a purple hue

    (b) 6.25×10^{-7}m

11. (a) (i) same frequency and constant phase difference

    (ii) pd = opd ÷ n

    (iii) (A) opd = (m + 1/2)l m = 0,1,2, ...

    (B) opd = ml m = 0,1,2, ...

    (iv) there is now a phase change of π at the lower surface on reflection, changing the conditions for constructive interference from opd = (m + 1/2)l to opd = ml

    (b) (i) opd for coating is such that the light reflected from the lens is out of phase by π with light reflected from surface of coating causing destructive interference (for one value of wavelength)

    (ii) (n = 1.38 for MgF_2) $l = 1.0 \times 10^{-7}$m

12. (a) (i) the waves oscillate in one 2-dimensional plane

(ii) signal becomes gradually weaker and disappears once the vertical position is reached

(b) (i) see notes

(ii) 56^{o}

13. (a) (i) 5.11×10^{-7} m

(ii) calculate total % unc; around 7.4%; 7.4% of $5.11 \times 10^{-7} = 3.7 \times 10^{-8}$ m

Round to 1 sig fig = $\pm 4 \times 10^{-8}$ m

(iii) unc. should be rounded to 1 sig fig (unless it will be '1')

(b) ±0.06 mm

(c) (i) there remains a 4% uncertainty in the measurement of slit separation which will dominate overall uncertainty calculated for wavelength

(ii) slit separation

14. (a) nodes

(b) (i) l = 176 mm $v = f\lambda = 352 \text{ ms}^{-1}$

(ii) measure the distance between a large number of minima - this will reduce the uncertainty in the measurement of wavelength

(c) reflected wave has a smaller amplitude so doesn't cancel out the wave from the speaker to as great an extent

15. (a) (i) (A) π rad (B) π rad

(ii) opd is made equal to 0.5 of wavelength so that reflected wave are out of phase by π radians and interfere destructively

(iii) more light is transmitted into camera, helping to increase quality (e.g. resolution) of image

(iv) (n = 1.38) 579 nm

(b) wavelength of sodium light l; length of glass plates L; distance between fringes viewed through microscope Dx

$$D = {}^{\lambda L}/_{2Dx}$$

16. (a) (i) light wave oscillates in one 2-dimensional plane

(ii) m = sin34.0÷sin48.0 = 0.752

(iii) 1.33 = tan i

i = 53^0

(b) 0.25^0

(c) image varies from bright to almost totally black when filter has turned half way to light again after 180^0

17. (a) polarised light's wave vibrations are restricted to a 2-dimensional plane, whilst unpolarised light's waves oscillate randomly all possible directions

(b) see notes

(c) i = 53^0

18. (a) polarised light's wave vibrations are restricted to a 2-dimensional plane, whilst unpolarised light's waves oscillate randomly all possible directions

(b) e.g. B 2.5 Wm^{-2} C 0 Wm^{-2}

D 2.5 Wm^{-2} E 5.0 Wm^{-2}

(c) see notes

19. (a) 614 nm (b) 8.6%

(c) measure the separation of more than 11 fringes, say 20; this will reduce the percentage error in the least accurate measurement

(d) division of wavefront

20. (a) polarised light's wave vibrations are restricted to a 2-dimensional plane, whilst unpolarised light's waves oscillate randomly all possible directions

(b) (i) liquid crystal doesn't allow light through so no light is reflected from mirror (looks dark) [molecules of crystal lined up by electric field so that they behave as an analyser at right angles to the polariser]

(ii) switch is opened

(c) numbers visible, then fade away to invisible at 90^0 and reappear gradually until fully visible again at 180^0

21. (a) (i) $D = {}^{ll}/_{2Dx}$

(ii) 6.5×10^{-5} m

(b) (i) 9.9×10^{-8} m

(ii) there is additional reflected light from the front of the liquid and no phase change (where there was a phase change of π rad at the surface of the coating) - the first will introduce light that has not been cancelled out by destructive interference whilst the second effect will result in constructive interference from the rays reflected from the coating and the lens)

(c) light reflected from the top of the oil interferes with light reflected from the water surface - for different thicknesses of oil, different wavelengths experience destructive interference leaving other colours to be reflected

22. (a) l = 0.300 m, f = 250 Hz

$v = fl = 0.300 \times 250 = 0.75$ ms $^{-1}$

(b) % distance = 3.3% % frequency = 4%

Total % = 5.2%

Absolute uncertainty = 5.2% of 75 = 3.9

$v = (75 \pm 4)$ms $^{-1}$

(c) (i) this will result in the distance between adjacent nodes halving which will double its uncertainty to over 6%, making absolute uncertainty in speed larger

(ii) measure distance between more than than two adjacent nodes to reduce uncertainty in the distance

23. (a) division of wavefront

(b) 3.1×10^{-4} m

(c) (i) reduces uncertainty in measurement of the fringe separation

(ii) brightness of fringes reduced so less distinct