T9-1 *[232 marks]*

1.

[1 mark]

Markscheme

A

Examiners report

[N/A]

2.

[1 mark]

Markscheme

C

Examiners report

[N/A]

3.

[1 mark]

Markscheme

A

Examiners report

[N/A]

4.

[1 mark]

Markscheme

B

Examiners report

[N/A]

5.

[1 mark]

Markscheme

D

Examiners report

[N/A]

6a. *[2 marks]*

Markscheme

(i) the work done per unit charge in moving a quantity of charge completely around a circuit / the power delivered per unit current / work done per unit charge made available by a source;

(ii) place voltmeter across battery;

Examiners report

[N/A]

6b. *[2 marks]*

Markscheme

(periodic) motion in which acceleration/restoring force is proportional to the displacement from a fixed point;

directed towards the fixed point / in the opposite direction to the displacement;

Examiners report

[N/A]

6c. *[4 marks]*

Markscheme

(i) $\omega = (2\pi f = 2\pi \times 1250)\,7854$ rad s^{-1};

$a_0 = (-\omega^2 x_0 = -7854^2 \times 0.85 \times 10^{-3} =)\ (-)5.2 \times 10^4\ ms^{-2}$;

(ii) correct substitution into
$E_T = \frac{1}{2} m \omega^2 {x_0}^2$ irrespective of powers of 10;

0.14 to 0.15 J;

Examiners report

[N/A]

6d. *[2 marks]*

Markscheme

(i) 0.264 m;

(ii) longitudinal;

progressive / propagate (through the air) / travels with constant speed (through the air);

series of compressions and rarefactions / high and low (air) pressure;

Examiners report

[N/A]

6e.

[6 marks]

Markscheme

(i) S leads L / idea that the phase of L is the phase of S minus an angle;

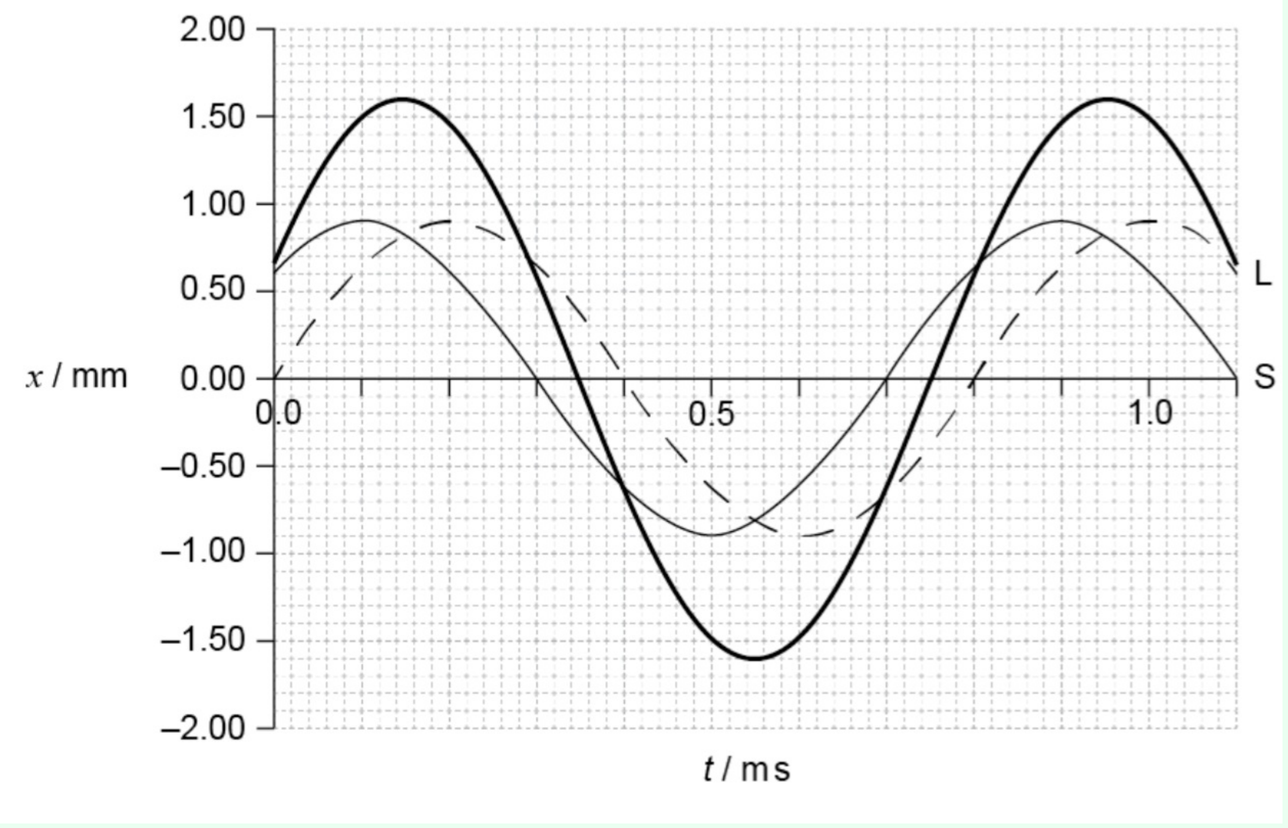
$\frac{1}{8}$ period / 1×10^{-4} s / 0.1 ms;

$\frac{\pi}{4}$ / 0.79 rad / 45 degrees;

(ii) agreement at all zero displacements;

maxima and minimum at correct times;

constant amplitude of 1.60 mm;



Examiners report

[N/A]

7a.

[2 marks]

Markscheme

ma
$= -kx$;
$a = -\frac{k}{m}x$; (*condone lack of negative sign*)
$\left(\omega^2 = \frac{k}{m}\right)$

or

implied use of defining equation for simple harmonic motion $a = -\omega^2 x$;
$\left(\text{so}\omega^2 = \frac{k}{m}\right)$
$ma = -kx$ so $a = -\left(\frac{k}{m}\right)x$;

Examiners report

[N/A]

7b. *[3 marks]*

Markscheme

(i) 0.833 (Hz);

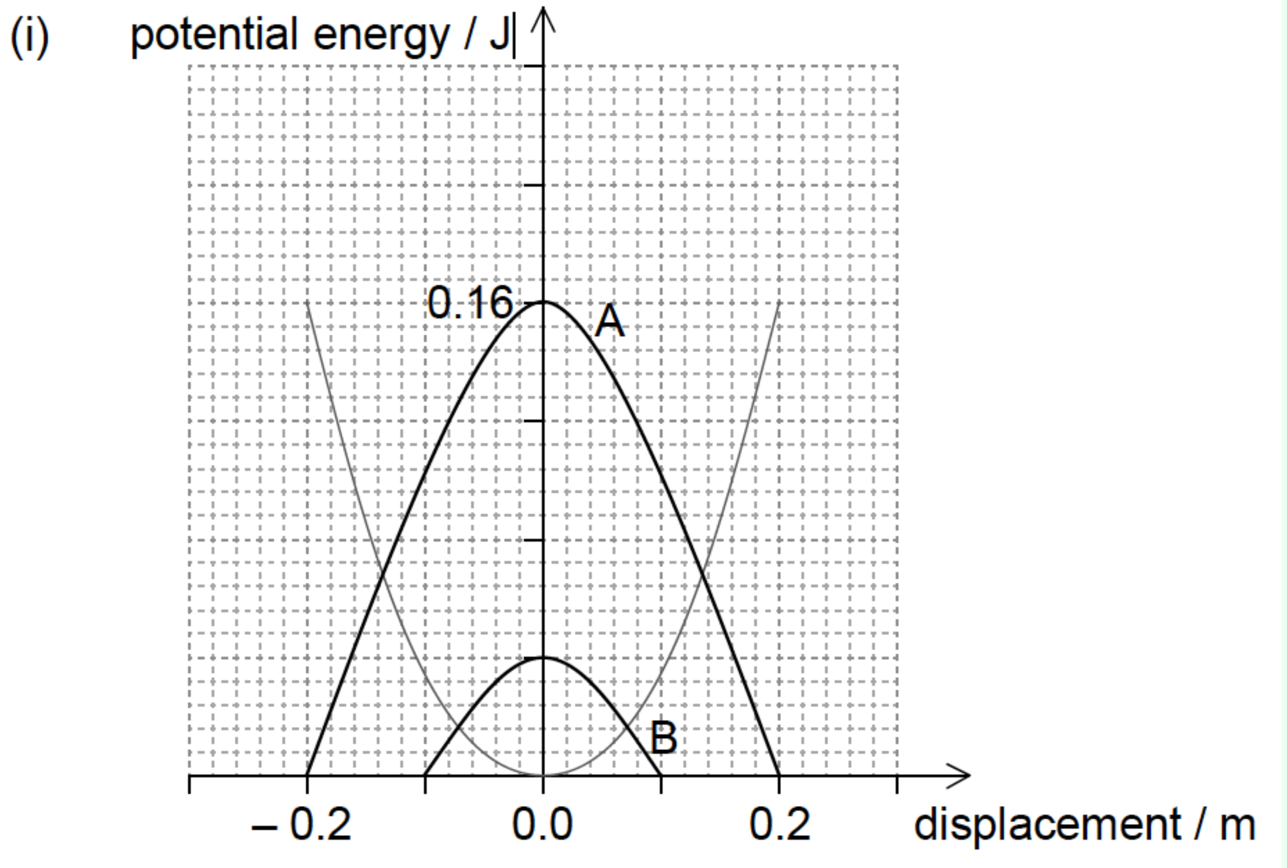
(ii) frequency/period is the same so ω is the same;
k is the same (as springs are identical);
(so *m* is the same)

Examiners report

[N/A]

7c. *[5 marks]*

Markscheme



correct shape;
maximum at 0.16 J;

(ii) end displacements correct ± 0.01m;
maximum lower than 0.16J;
maximum equal to 0.04J ± half square;

Examiners report

[N/A]

7d.

[4 marks]

Markscheme

(i) $l = \frac{\pi d^2 R}{4\rho}$ seen / correct substitution

into equation: $24 = \frac{l \times 1.7 \times 10^{-8}}{\pi \times \left(0.15 \times 10^{-3}\right)^2}$; } (*condone use of r for* $\frac{d}{2}$ *in first alternative)*

99.7 (m);
*Award **[2]** for bald correct answer.*
*Award **[1 max]** if area is incorrectly calculated, answer is 399 m if conversion to radius ignored, ie: allow ECF for second marking point if area is incorrect provided working clear.*

(ii) any line showing resistance decreasing with increasing diameter **and** touching point;
correct curved shape showing asymptotic behavior on at least one axis;

Examiners report

[N/A]

7e.

[3 marks]

Markscheme

current/conduction is (related to) flow of charge;
conductors have many electrons free/unbound / electrons are the charge carriers / insulators have few free electrons;
pd/electric field accelerates/exerts force on electrons;
smaller current in insulators as fewer electrons available / larger current in conductors as more electrons available;

Examiners report

[N/A]

7f.

[8 marks]

Markscheme

(i) use of total resistance = 11Ω; *(can be seen in second marking point)*
$\frac{1}{11} = \frac{1}{R} + \frac{1}{24}$;
20.3(Ω) ;

(ii) as current is same in resistor network and cell and resistance is same, half of emf must appear across resistor network;
6.0 (V);

or

$I = \frac{12}{(11+11)} = 0.545\,(\mathrm{A})$;
V=(0.545×11=) 6.0 (V);

Other calculations are acceptable.
*Award **[2]** for a bald correct answer.*

(iii) use of 22 (ohm) ***or*** 11+11 (ohm) seen;
use of $\frac{V^2}{R}$ or equivalent;
6.54 (W);
*Award **[3]** for bald correct answer.*
*Award **[2 max]** if cell internal resistance ignored, yields 3.27 V.*

Examiners report

[N/A]

8a. *[3 marks]*

Markscheme

mention of interference;
interference is between reflected waves from both reflectors;
minimum caused (by destructive interference) when crest meets trough/when path difference is
$\frac{\lambda}{2}$ / (completely) out of phase / phase difference of
π/180º / *OWTTE*;
minimum occurs when twice the distance between plates is
$\left(n+\frac{1}{2}\right)\lambda$;

Ignore references to standing waves.

Examiners report

[N/A]

8b. *[3 marks]*

Markscheme

(i) spreading out of a wave; *(do not allow "bending" even if context is obstacle)*
when it meets an aperture/gap/slit/obstacle;
Allow credit for answers appearing on clear labelled diagram for both marks.

(ii)
$\left(\theta=\frac{32}{60}=\right)0.533\,(\mathrm{rad})$ ***or*** 30.6(º);
*Award **[0]** for calculation that uses 1.22 (0.65 rad).*
*Award **[0]** for 0.533º or 30.6 rad.*
At least one centre is using the abbreviation ᶜ for rad. Please allow this.

Examiners report

[N/A]

8c. *[2 marks]*

Markscheme

sound waves (in air) are longitudinal;
longitudinal waves cannot be polarized / only transverse waves can be polarized;

*Award **[0]** for any suggestion that ultrasound is an electromagnetic wave.*

Examiners report

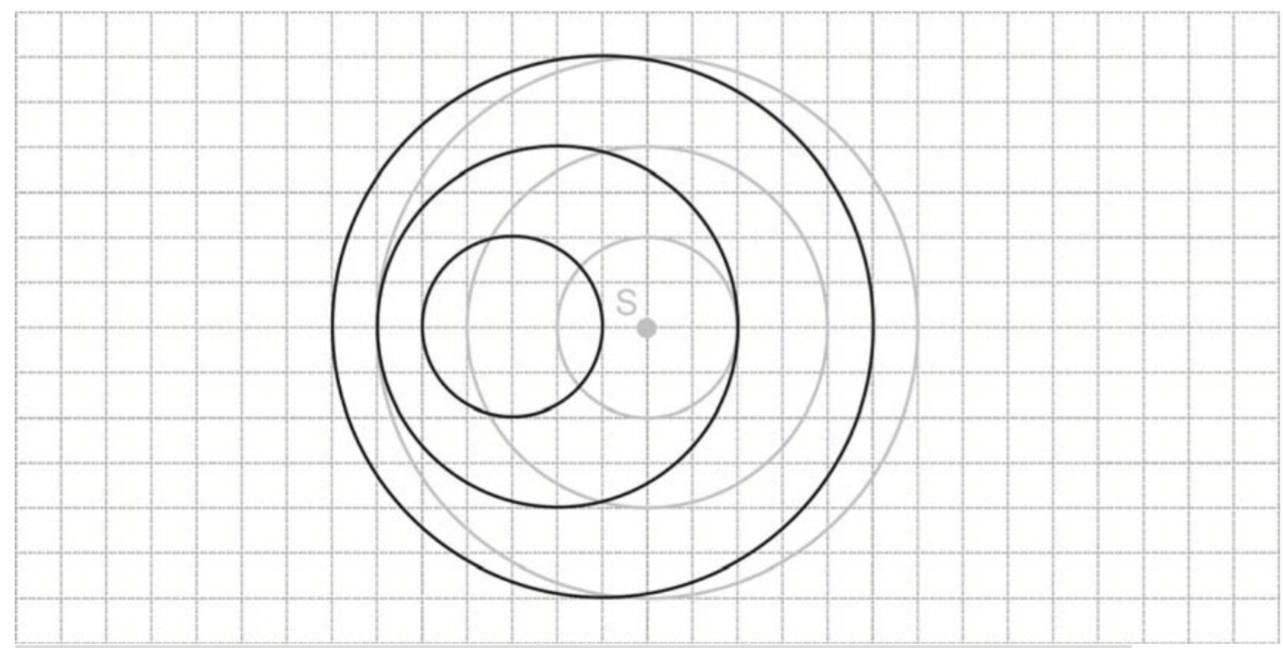
[N/A]

9a.

[2 marks]

Markscheme

3 circular wavefronts;
2 centres/sources of wavefronts move left (by one box);



Drawn circular wavefronts may be larger as in diagram here, or could be equal sized. Both are acceptable.

Examiners report

[N/A]

9b.

[3 marks]

Markscheme

(i)

$v = \frac{5 \times 10^{-16} \times 3 \times 10^{8}}{7.5 \times 10^{-9}}$;

20(ms^{-1});

Use of sound equation not acceptable.

(ii) assume speed of X-rays $= c$ / assume speed of turntable << c;

Examiners report

[N/A]

10a.

[3 marks]

Markscheme

light reflects from the top surface of the oil and the top surface of the water;
mention of interference/superposition;
path difference exists between both reflected rays;
different wavelengths interfere constructively for different positions/angles (hence colours appear/shift);

Examiners report

[N/A]

10b. *[2 marks]*

Markscheme

$\lambda \left(= t\frac{2n}{m}\right) = 250 \times 10^{-9}\,\frac{2\times 1.4}{1}$;
$\lambda = 700\,(\text{nm})$;

Examiners report

[N/A]

11a. *[2 marks]*

Markscheme

diffraction angle=0.05 rad;
$b = \left(\frac{\lambda}{\theta} = \frac{7.0\times 10^{-7}}{0.050} =\right) 1.4 \times 10^{-5}\,(\text{m})$; *(do not accept use of 1.22)*

*Award **[2]** for a bald correct answer.*

Examiners report

Parts (a) and (b) on single slit diffraction were well answered.

11b. *[1 mark]*

Markscheme

same shape with narrower central maximum;
Ignore height of intensity peak.

Examiners report

Parts (a) and (b) on single slit diffraction were well answered.

11c. *[2 marks]*

Markscheme

blue light gives better resolution;
blue light has shorter wavelength than red light;
giving smaller angle of diffraction;
Allow reverse argument for red light.

Examiners report

However there were fewer correct answers for part (c) where effect of the different wavelengths of red and blue light were sometimes confused and the smaller θ interpreted as poorer resolution. Often the ability to resolve was explained incorrectly in terms of the intensity of the graphs drawn.

12a. *[2 marks]*

Markscheme

reference to:
diffraction at slits / slits are coherent sources;
path/phase difference;
constructive and destructive interference;
Do not reward just "interference" as this is mentioned in the question.

Examiners report

In part (a) diffraction at each slit, followed by a path difference and subsequent constructive or destructive interference was very often given, but sometimes in a clumsy fashion. It is evident that not all candidates take 30s to plan the order in which they are going to present the steps in their argument.

12b. *[2 marks]*

Markscheme

for single fringe:

$s = \frac{650\times10^{-9}\times1.8}{2.2\times10^{-3}} \left(= 5.3\times10^{-4}\ (\mathrm{m})\right);\}$ *(also award this mark if the factor of 3 is seen in the numerator)*

distance

$MP = \left(5.3\times10^{-4}\times3=\right) 1.6\times10^{-3}\ (\mathrm{m});$

Allow ECF from first marking point.

*Award **[2]** for a bald correct answer.*

Examiners report

Part (b) was not difficult, but many lost 1 mark for not using n = 3. Highlight this fact in the stem and these kind of careless errors can be avoided.

13. *[1 mark]*

Markscheme

D

Examiners report

14. *[1 mark]*

Markscheme

A

Examiners report

The vast majority of candidates understood that the fractional change in the wavelength was needed and hence discounted B or D. But it would seem that they did not read the stem carefully, where it is clear that the wavelength has decreased – indicating that it is travelling towards Earth.

15. *[1 mark]*

Markscheme

A

Examiners report

[N/A]

16. *[1 mark]*

Markscheme

D

Examiners report

[N/A]

17. *[1 mark]*

Markscheme

C

Examiners report

[N/A]

18. *[1 mark]*

Markscheme

A

Examiners report

It is logical that as D increases so the width of the central maximum will increase. Hence B and D (both with D on the denominator) can be eliminated. A sketch of the graph of the diffraction pattern for a single slit will show that A is correct.

19a. *[5 marks]*

Markscheme

(i) diagram showing (circular) wavefronts around source, so that wavefronts are closer together on side of observer;
speed of sound waves for observer is the same (as for stationary case) but observed wavelength is smaller;

since $f' = \frac{v}{\lambda'}$, (observed frequency is larger);

(ii) $f' \left(= f \left[\frac{v}{v - u_s} \right] \right) = 275 \left[\frac{330}{330 - 20} \right]$;
=293(Hz);

*Award **[0]** for use of moving observer formula.*
*Award **[1]** for use of* $v+u_s$ *to give 259 (Hz).*
*Award **[2]** for a bald correct answer.*

Examiners report

ai) Many candidates scored the first mark for the diagram showing the wavefronts closer on the side of the observer but most of the written explanations just repeated this and didn’t expand further.

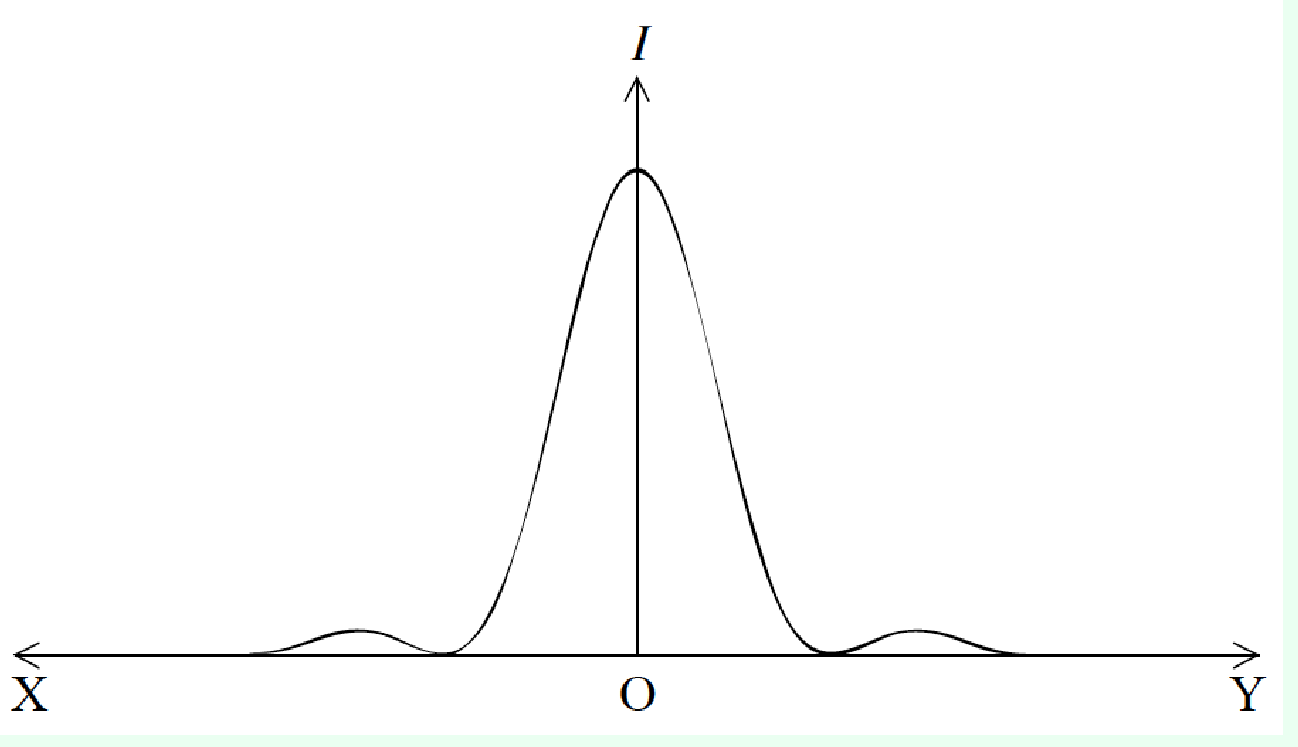
aii) This question was very well answered with the majority of candidates choosing the appropriate formula and evaluating correctly.

19b. *[4 marks]*

Markscheme

(i) central symmetrical maximum;
at least one secondary maximum on each side, no more than one third the height of the central maximum; { *(judge by eye)*

minima drawn to zero, *ie* touching axis;
width of the secondary maximum half the width of the primary maximum; { *(judge by eye)*



(ii) greater distance between maxima/minima / pattern more spread out;

Examiners report

bi) Most candidates were able to score full marks on this question.

bii) Again this was answered successfully.

19c. *[3 marks]*

Markscheme

(i) in a polarized wave, the <u>oscillations</u>/<u>vibrations</u> are in one direction/plane only;
in an unpolarized wave, the oscillations/vibrations are in all directions/ planes (perpendicular to the direction of energy transfer);
Must see mention of oscillations or vibrations in first or second marking point.

(ii) sound waves are longitudinal / the oscillations/vibrations are always parallel to direction of energy transfer;

Examiners report

ci) Few candidates included the words oscillations or vibrations in their answers and consequently scored zero marks.

cii) Many recognized that sound waves are longitudinal and that is why they cannot be polarized.

20. *[1 mark]*

Markscheme

C

Examiners report

The candidates found this question to be the most difficult of the paper, with the correct answer being the least often selected! The key to spotting the correct solution is a simple diagram showing that after the particle has travelled a distance of $x_0/3$ then its distance to the equilibrium position is $2x_0/3$. Substituting this value into the relevant equation in the Data Booklet gives response C directly.

21.

[1 mark]

Markscheme

A

Examiners report

[N/A]

22.

[1 mark]

Markscheme

B

Examiners report

[N/A]

23.

[1 mark]

Markscheme

C

Examiners report

A was a popular choice, indicating that some candidates were unsure of the relationship between the number of photons per second in a light wave, the intensity of the wave and its frequency.

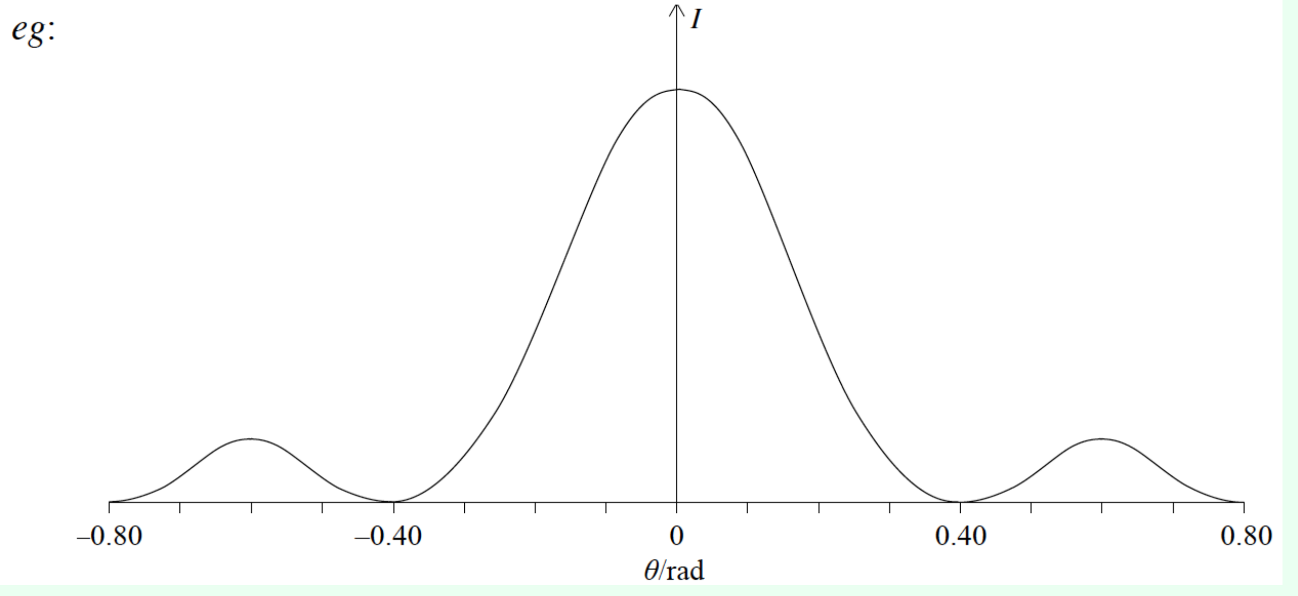
24.

[4 marks]

Markscheme

(i) $\theta = \frac{1.22 \times 59 \times 10^{-6}}{0.18 \times 10^{-3}}$;
(=0.40rad)

(ii) central symmetrical maximum;
at least one secondary maximum on each side, no more than one third the height of the central maximum; *(judge by eye)*
minima drawn to zero, *ie* touching axis at θ=±0.40 (and ±0.80);



Examiners report

[N/A]

25a.

[5 marks]

Markscheme

(i) $f_1 = \frac{v}{4L}$, $f_2 = 3f_1 = \frac{3v}{4L}$;
$f_2 - f_1 = \frac{v}{2L} = 820\,(\text{Hz})$;
$L = \frac{330}{2 \times 820}$;
(L=0.20m)

(ii) $\lambda = 4L = 0.80\,(\text{m})$;
$f = \left(\frac{330}{0.8}\right) = 413\text{Hz}$;

This is a question testing units for this option. Do not award second marking point for an incorrect or missing unit.

Examiners report

[N/A]

25b.

[4 marks]

Markscheme

(i) a change in the observed frequency/wavelength of a wave;
when there is relative motion of observer and source;

(ii) $f' \left(= f\frac{v}{v-u_s}\right) = 410 \times \frac{330}{330-50}$;
$f' = 480\,(\text{Hz})$;
Allow ECF from (a)(ii).

Examiners report

[N/A]

26a. *[2 marks]*

Markscheme

$\lambda = (2D\tan\theta =)\, 2 \times 0.30 \tan 10^{-3}$ ***or*** $2 \times 0.30 \sin 10^{-3}$;
$\lambda = 6.0 \times 10^{-7}$ (m);
*Award **[1 max]** for use of degrees instead of radians giving*
$\lambda = 1.0 \times 10^{-8}$ (m).

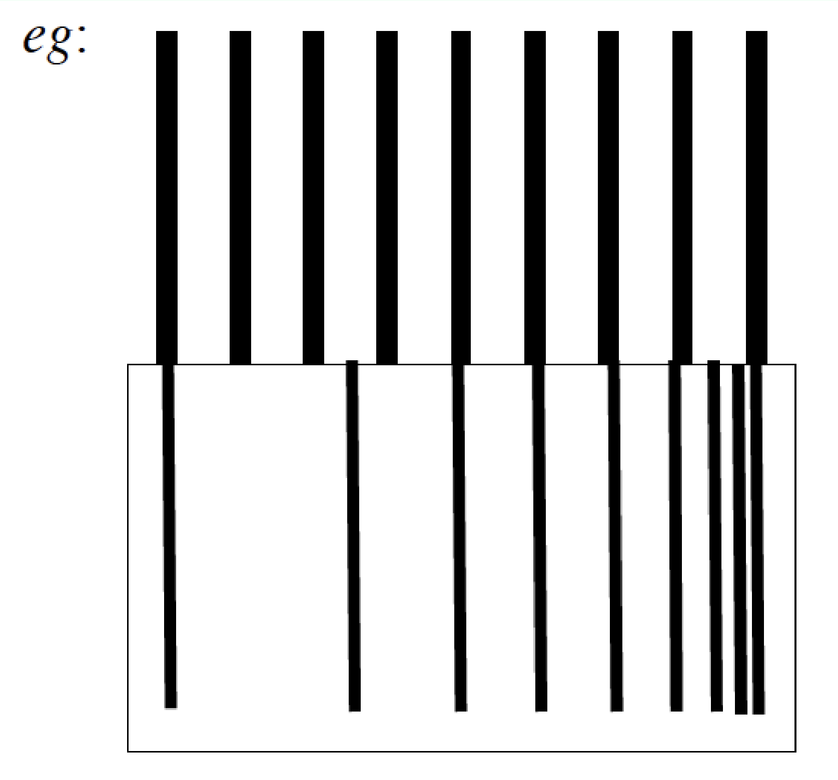
Examiners report

This part of syllabus does not appear to be well understood. Some candidates calculated the wavelength but many used the formula from the data booklet without explanation. Only a few analysed the situation well. Even the well prepared candidates had a problem with the radian angle unit. The majority of candidates found the change in shape of one of the plates very difficult. Only a few candidates realized that the number of fringes must not change.

26b. *[2 marks]*

Markscheme

decreasing distance from left to right;
distance larger than original at left and shorter than original at right;



Examiners report

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27. *[1 mark]*

Markscheme

C

Examiners report

[N/A]

28. *[1 mark]*

Markscheme

B

Examiners report

[N/A]

29. *[1 mark]*

Markscheme

C

Examiners report

[N/A]

30. *[1 mark]*

Markscheme

D

Examiners report

[N/A]

31. *[1 mark]*

Markscheme

A

Examiners report

[N/A]

32a. *[3 marks]*

Markscheme

(i) 32 (mm);

(ii) period = 160 (ms);

frequency = 6.2/6.3 (Hz);

Allow ECF for incorrect period.

Examiners report

(i) Nearly all candidates correctly stated the amplitude as being 32 mm.

(ii) Most were able to measure the period and many then went on to calculate the frequency with the occasional hiccup with conversion of ms into kHz etc.

32b. *[4 marks]*

Markscheme

(i) $\omega = 2\pi \times 6.25$;
$v (= 39.3 \times 32 \times 10^{-3}) = 1.3 (\text{ms}^{-1})$; *(allow ECF from (a))*

or

tangent drawn to graph at a point of zero displacement;

gradient calculated between 1.2 and 1.4;

(ii) displacement = 23–26 (mm);

35–40 (ms^{-2});

23 mm found by calculating displacement

Examiners report

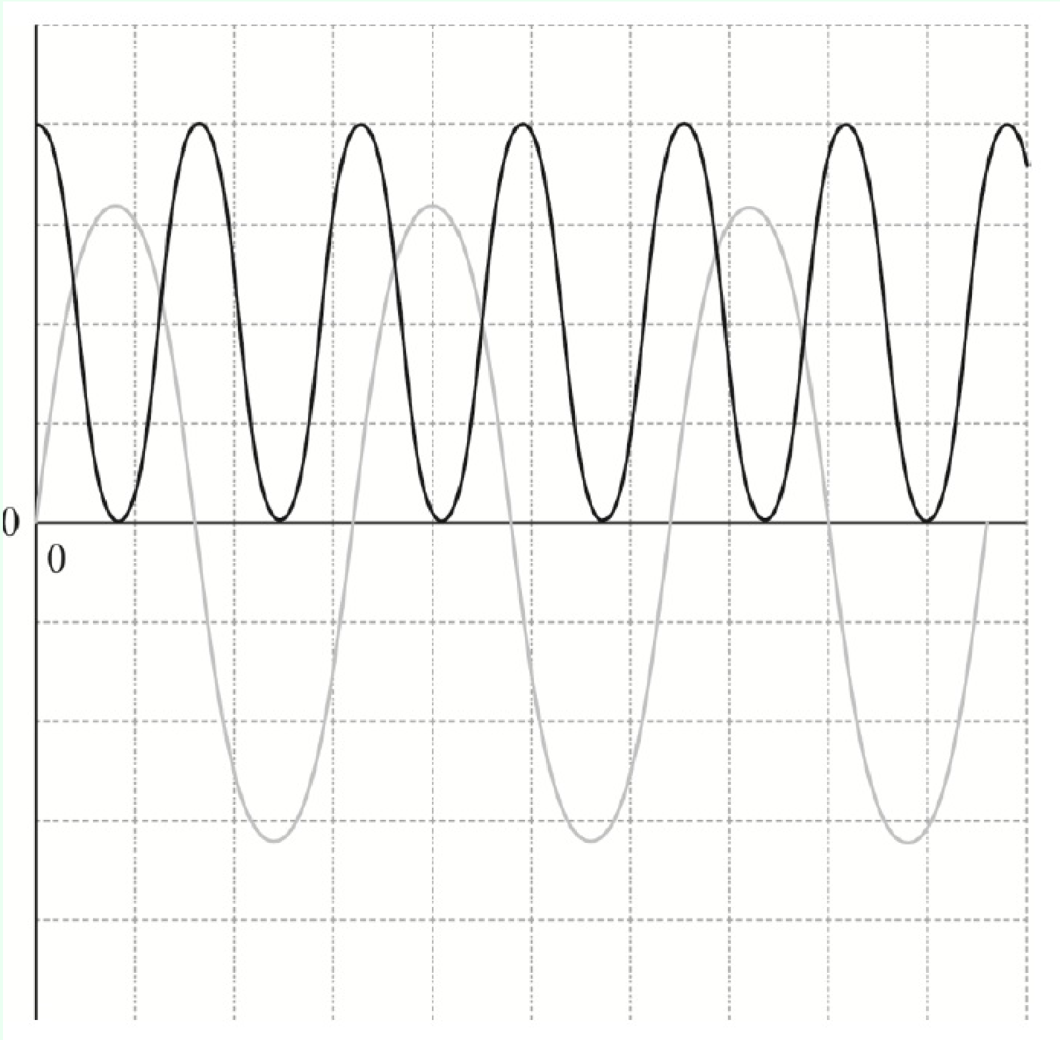
(i) A large proportion of candidates correctly determined the maximum speed of the object by correctly calculating the angular speed and multiplying it by the amplitude. Full marks were awarded to those calculating the gradient of the tangent to the displacement-time graph at zero displacement.

(ii) In the simplest route to the answer candidates were usually successful in measuring the displacement at 140 ms and then using the defining equation for SHM to calculate the acceleration. Other routes were allowed as alternatives but success was infrequent.

32c.

[3 marks]

Markscheme



double frequency;

always positive and constant amplitude;

correct phase *ie* cosine squared;

Ignore amplitude value.

*A minimum of one complete, original oscillation needed to award **[3].***

Examiners report

Given the relative difficulty of transposing the displacement into a velocity and then squaring it to find the shape of the kinetic energy function, this part was done very well. Most candidates recognised that the energy was always positive, of twice the frequency of the displacement graph and took a cosine squared shape. Sketches were of variable quality but often better than others on the paper.

33a.

[3 marks]

Markscheme

$\left(\text{since}\frac{v}{c} \ll 1\right)\Delta f \left(= \frac{v}{c}f\right) = \frac{6.0\times10^6}{3.0\times10^8}6.0 \times 10^9 \left(= 0.12 \times 10^9 \text{Hz}\right)$;

$f' = f - \Delta f \left(= 5.9 \times 10^9 \text{Hz}\right)$;

$\lambda' \left(= \frac{c}{f'} = \frac{3.00\times10^8}{5.9\times10^9}\right) = 5.1 \times 10^{-2}\ (\text{m})$;

*Award **[2 max]** if f'=f+Δf used to give* λ'=4.9x10^{-2}(m).

Examiners report

was well done by some, although many used the equation appropriate for sound not the approximation for light where c >> v.

33b.

[4 marks]

Markscheme

(i) the two (point-like) sources generate diffraction patterns with central maxima;
the central maximum of one pattern overlaps with the first minimum of the second diffraction pattern;

(ii) $\theta \approx \frac{d}{D} = \frac{5.0\times10^{19}}{2.0\times10^{21}} = 0.025(\mathrm{rad})$
$\left(b > 1.22\frac{5.1\times10^{-2}}{0.025} =\right) 2.5\,(\mathrm{m})$;

Allow ***[1 max]*** *for solution that omits 1.22.*

Examiners report

In (b) (i) candidates often got the first mark by implication when gaining second mark. There was a lot of confused algebra in (b)(ii).

34a.

[1 mark]

Markscheme

-3;

Examiners report

Many candidates knew about the idea of strangeness, but did not assign a numerical value.

34b.

[2 marks]

Markscheme

(i) anti u (quark) /$\bar{u}$;
(ii) W^{-};

Examiners report

Was reasonably well answered.

34c.

[2 marks]

Markscheme

principal maxima broaden;

secondary maxima appear;

Examiners report

There were almost no correct answers. Candidates clearly need a lot of practice answering questions on the diffraction grating.

35a. *[3 marks]*

Markscheme

(i) single frequency/wavelength / narrow range of frequencies/wavelengths;

(ii) in phase;
constant phase difference/relationship;

*Award **[2]** for any correct reference to constant phase difference.*

Examiners report

(i) was very well done.

Many candidates got one mark for "in phase" in (ii), but few got two marks for "constant phase difference" even though this is the standard definition for coherence. This is a standard question that has been in several papers over the last few years. Teachers and candidates should take note of the following clarification - there can be two sources which are in phase (that is, have exactly the same phase) and so are coherent. There can also be two sources which have different phases at any one instant but have a constant phase difference/relationship and so are coherent. Thus "constant phase difference" is a better answer than "in phase" because "in phase" is a special case of "constant phase difference" (that is, the constant phase difference is zero).

35b. *[4 marks]*

Markscheme

$\theta = \tan^{-1}\left[\frac{0.65}{2.0}\right](= 18^\circ)$;
recognition that *n*=1;
$d = \frac{1}{600}(= 0.0017\mathrm{mm})$;
λ=(=*d* sin θ = 0.0017 x sin18º) = 520(mm);

Examiners report

Most candidates used the equation for double-slit interference rather than the equation for diffraction grating. Candidates appear to be far more comfortable with the double-slit case than the diffraction grating case.

36a. *[2 marks]*

Markscheme

the acceleration of piston/P is proportional to its displacement from equilibrium;
and directed towards equilibrium;
*There must be a clear indication what is accelerating otherwise award **[1 max]**.*

Examiners report

Candidates were asked to define SHM as applied to the situation in the question. Many failed to do this and wrote in general terms about SHM.

36b. *[7 marks]*

Markscheme

(i) 12(cm); (*accept* –12)

(ii) any maximum or minimum of the graph;

(iii) period= 0.04 (s); *(allow clear substitution of this value)*
$\omega = \left(\frac{2\pi}{T} =\right) \frac{2\times3.14}{0.04} = 157\left(\text{rads}^{-1}\right)$

maximum acceleration=($A\omega^2$=)0.12×157^2=3.0×10^3(ms^{-2}); *(watch for ECF from wrong period)*

(iv) at t=0.052sx=(-)4(±1)cm;
$\text{KE} = \left(\frac{1}{2}m\omega^2\left[A^2 - x^2\right] =\right) 0.5\times0.32\times157^2\left[0.12^2 - 0.04^2\right] = 50\,(\pm7)\,(\text{J});$

Watch for incorrect use of cm.
Allow ECF from calculations in (b)(iii).
Do not retrospectively credit a mark for ω to (b)(iii) if it was not gained there on original marking.
Allow use of sin ωt to obtain v.
*Award **[2]** for a bald correct answer.*

Examiners report

(i) This was well done.

(ii) Almost all candidates were able to identify a correct point for the maximum acceleration.

(iii) and (iv) Solutions for these were confused. Some attempted to use kinematic equations. Others mixed metres and centimetres in their answers. Other algebraic errors were present too (e.g. confusing $12^2 - 4^2$ for $(12 - 4)^2$). This is an area that candidates could practice more.

36c. *[4 marks]*

Markscheme

(i) the direction of the oscillations/vibrations/movements of the particles (in the medium/gas);

for a longitudinal wave are parallel to the direction of the propagation of the energy of the wave;

(ii) $f = \left(\frac{1}{T} =\right)\frac{1}{0.04} = 25\,(\text{Hz});$
$\lambda = \left(\frac{v}{f} =\right)\frac{340}{25} = 14\,(\text{m});$

*Award **[1 max]** if frequency is not clearly stated.*
Allow ECF from calculations in (b)(iii).

Examiners report

(i) There were three marks for this question: for distinctions between longitudinal and transverse and for a clear description of the point of comparison. The latter was the mark most frequently lost. Many candidates have the vague idea that something about transverse is perpendicular and that the same parameter is parallel for longitudinal, but what “that something” is was frequently confused.

(ii) Candidates are now taking more care over the clear declaration of the frequency leading to the wavelength.

37. *[1 mark]*

Markscheme

A

Examiners report

This question was very poorly answered. There are many graphs associated with simple harmonic motion (SHM) which are sinusoidal, but these are the graphs with *time* on the horizontal axis. Having *displacement* on the axis, though, will produce different graphs and candidates should be equally familiar with these. In this case it should have been clear that at the extremities of SHM velocity will be zero, while at the equilibrium point it will be maximum. So the only possible answer is A, showing half a cycle of SHM.

38.

[1 mark]

Markscheme

D

Examiners report

[N/A]

39.

[1 mark]

Markscheme

A

Examiners report

[N/A]

40.

[1 mark]

Markscheme

C

Examiners report

[N/A]

41a.

[2 marks]

Markscheme

the observed change in frequency/wavelength of a wave;
emitted by a source moving away from or towards/relative to the observer;

Examiners report

[N/A]

41b.

[4 marks]

Markscheme

(i) a blue-shift / towards the blue end of the spectrum / to a higher frequency / *OWTTE*;

(ii) $v = \left(\frac{c\Delta f}{f} =\right) \frac{3\times10^{8}\times1.3\times10^{12}}{4.6\times10^{16}}$;
$8.5\times10^{3}\text{ms}^{-1}$;
assume that the speed is very much less than speed of light;

Examiners report

[N/A]

41c. *[5 marks]*

Markscheme

(i) the two stars are (just) seen as separate images;
if the central maximum of the diffraction image of one star coincides with the first minimum of the diffraction image of the other star / *OWTTE*;
Accept an appropriate diagram for second marking point.

(ii) $\theta = \left(\frac{1.22\lambda}{b} =\right) \frac{1.22 \times 4.8 \times 10^{-7}}{5.0 \times 10^{-2}}$ ***or*** 1.17×10^{-5}rad;
$\theta = \frac{d}{1.0 \times 10^{18}}$;
(d=)1.2×10^{13}m;
*Award **[2 max]** if 1.22 is missing, giving an answer of 0.98×10^{13}.*

Examiners report

[N/A]

42. *[3 marks]*

Markscheme

there are $\frac{60}{0.29}$ fringes=207;
$2\times1\times t=207\times5.9\times10^{-7}$;
t=61(µm);

or

$(\tan\theta =)\ \frac{1}{6.0(\text{cm})} = \frac{0.5\lambda}{\Delta x}$;
$t = \frac{[0.06(\text{m}) \times 0.5 \times 5.9 \times 10^{-7}(\text{m})]}{0.00029(\text{m})}$;
t=61(µm);
A phase change of
$\frac{1}{2}\lambda$*, if seen in working, can be ignored and does not affect the answer.*
*Award **[3]** for a bald correct answer.*

Examiners report

[N/A]

43a. *[2 marks]*

Markscheme

observed/perceived change in pitch/frequency;
when there is relative motion between source and observer;

Examiners report

[N/A]

43b. *[3 marks]*

Markscheme

recognize that $f' = \left[\frac{v}{v-u_s}\right] f$;

$566 = \left[\frac{v}{v-28}\right] 520$;

to give *v*=345(ms^{-1}) ;

*Award **[0]** for use of the moving observer Doppler equation.*

*Award **[2 max]** for the use of +28 to give -345(ms^{-1}).*

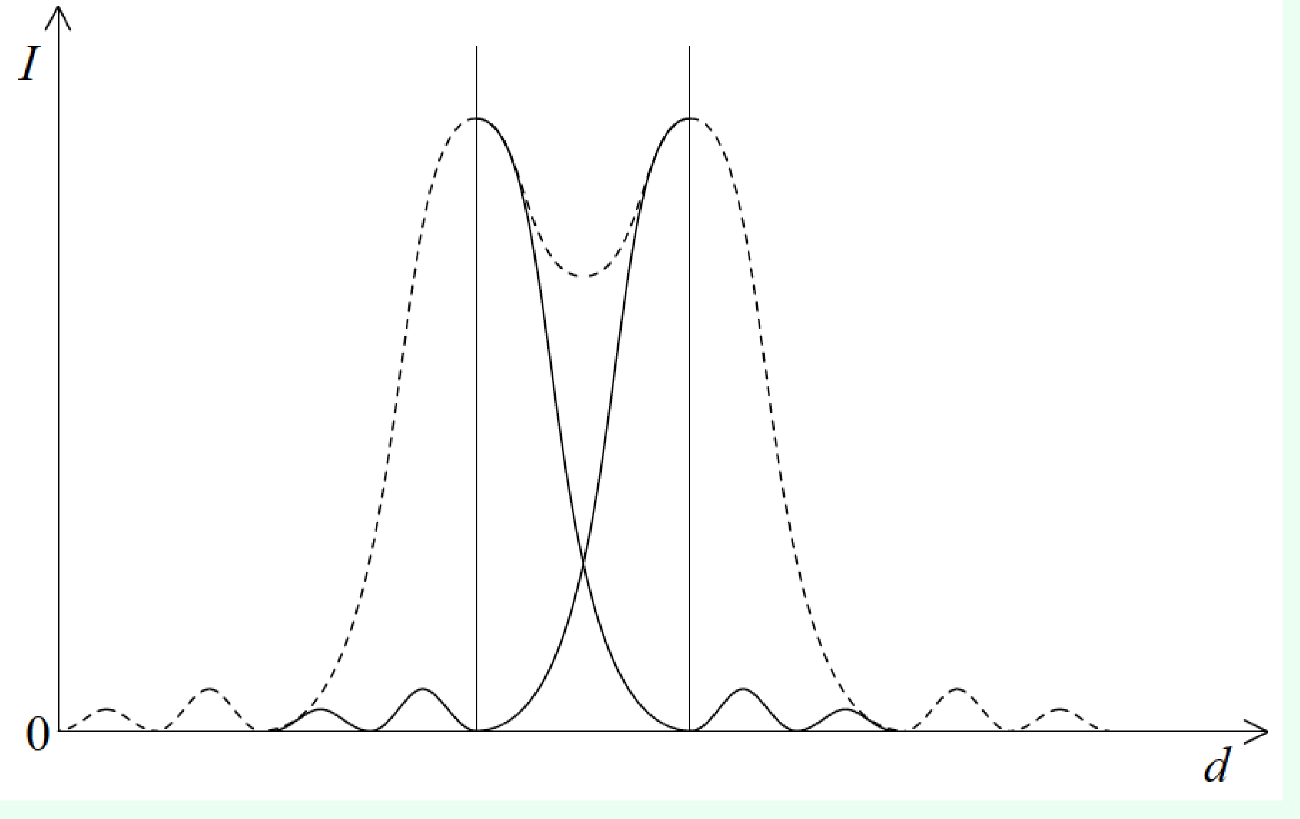
Otherwise award only the first marking point for substitution of the incorrect values in the correct equation.

Examiners report

[N/A]

44a. *[3 marks]*

Markscheme



correct shape of two diffraction patterns showing central maximum and at least one secondary maximum each side of central maximum;

intensity of secondary maxima no greater than one third intensity of central maxima; } *(judge by eye)*

first minimum of one pattern coincident with central maximum of other pattern;

or

Allow just the approximate dotted resultant intensity patterns:

correct pattern of two symmetrical principal maxima;

with local minimum between them;

at least one secondary maximum on each side which are no more than $\frac{1}{3}$ of the intensity of the principal maxima;

Examiners report

[N/A]

44b. *[3 marks]*

Markscheme

angular separation for resolution=$1.22\frac{\lambda}{b}=1.22\times\frac{5.0\times10^{-7}}{1.9\times10^{-3}}=\left(3.21\times10^{-4}\right)(\text{rad})$;

$=\frac{1.4}{d}$;

d=4.4(km);

*Award **[2 max]** if 1.22 not used and answer is 5.3 km.*

*Award **[3]** for a bald correct answer.*

Examiners report

[N/A]

44c. *[1 mark]*

Markscheme

light in which the electric/magnetic field (vector) vibrates only in one plane/direction;

Examiners report

[N/A]

45a. *[1 mark]*

Markscheme

the maximum displacement of the system from equilibrium/from centre of motion / *OWTTE*;

Examiners report

45b. *[5 marks]*

Markscheme

(i) the amplitude of the oscillations/(total) energy decreases (with time); because a force always opposes direction of motion/there is a resistive force/ there is a friction force;

Do not allow bald "friction".

(ii) $\omega=\sqrt{\frac{2g}{l}}$;

$T=2\pi\sqrt{\frac{0.32}{2\times9.81}}$;

=0.80s;

Examiners report

45c.

[9 marks]

Markscheme

(i) upwards;

(ii) y_0 = 0.050(m) and y = 0.030(m);
$\omega = \left(\frac{2\pi}{0.80} =\right) 7.85 \left(\text{rads}^{-1}\right)$;
$v = 7.85\sqrt{[0.05]^2 - [0.03]^2}$;
=0.31ms^{-1} ; (*allow working in cm to give 31 cms^{-1}*);

(iii) λ=4.0m;
recognition that $f = \frac{1}{0.80}(= 1.25)$;
($f\lambda$=)v=1.25×4.0;
(=5.0 ms^{-1})

(iv) y=-3.0 cm, d=0.6 m;

Examiners report

46a.

[7 marks]

Markscheme

(i) the amplitude of the oscillations/(total) energy decreases (with time); because a force always opposes direction of motion/there is a resistive force/ there is a friction force;
Do not allow bald "friction".

(ii) the displacement and acceleration/force acting on (the surface); are in opposite directions;

(iii)
$\omega = \sqrt{\frac{2g}{l}}$;
$T = 2\pi\sqrt{\frac{0.32}{2\times 9.81}}$;
=0.80s;

Examiners report

Candidates had some uncertainty in discussing the negative sign in the SHM equation for the U-tube example. They were unclear about the terms in the equation and the relative direction of the vector quantities concerned.

46b.

[6 marks]

Markscheme

(i) wave reflects at ends (of string);
interference/superposition occurs (between waves);
regions of maximum displacement/zero displacement form (that do not move);
one region of max displacement/antinode forms at centre with zero displacement/node at each end; {*(allow these marking points from clear diagram)*

(ii) the waves (in a string) are transverse and vibrate only in one plane;
light waves are transverse electromagnetic waves;
(and) for polarized light the electric field vector vibrates only in one plane;

Examiners report

(i) Although there were many suggestions that the wave is reflected at one end of the string and that this interferes in some way with the incident wave to produce the standing wave these were generally weak and incomplete. Some candidates focussed entirely on the shape of the standing wave (not really the question). It was rare to see 3 marks awarded; 2 was more common.

(ii) Candidates were vague as to the nature of polarized light (a clear description in terms of the field vectors was required), as to the description of the travelling wave on the string, and as to the way in which it could be used. Many will have seen the demonstration in the laboratory but could not describe it with clarity.

47a. *[3 marks]*

Markscheme

circular wavefronts around source, equally spaced;
moving observer intercepts more wavefronts per unit time / the time between intercepting successive wavefronts is less;
hence observes a higher frequency / ƒ′ > ƒ;
or
circular wavefronts around source, equally spaced;
the velocity of the sound waves with respect to the observer is greater;
since $f' = \frac{v'}{\lambda}$, observed frequency is also greater;

Examiners report

[N/A]

47b. *[2 marks]*

Markscheme

$f' = f\left(\frac{v+u_o}{v}\right) = 300\left(\frac{330+15}{330}\right)$;
=314 Hz;
*Award **[0]** for use of moving source formula.*
*Award **[1]** for use of v-u_o to give 286 Hz.*

Examiners report

[N/A]

48a. *[4 marks]*

Markscheme

$d = \frac{1}{8.00\times10^5} = 1.25\times10^{-6}\text{m}$;
$d\sin\theta = n\lambda \Rightarrow \theta\sin^{-1}\left[\frac{n\lambda}{d}\right]$;
$\sin^{-1}\left[\frac{2\times589\times10^{-9}}{1.25\times10^{-6}}\right] = 70.5°, \sin^{-1}\left[\frac{2\times590\times10^{-9}}{1.25\times10^{-6}}\right] = 70.7°$;
70.7°−70.5°=0.2°;

Examiners report

[N/A]

48b.

[1 mark]

Markscheme

the lines are closer together / not clearly separate in the first order spectrum;

Examiners report

[N/A]

49a.

[2 marks]

Markscheme

phase change of π occurs on reflection at one slide but not the other;

constructive interference occurs when path difference between two reflected rays is $\frac{\lambda}{2}$, $\frac{3\lambda}{2}$, $\frac{5\lambda}{2}$ etc;

the extra distance travelled is twice the thickness of the air (wedge) hence $2t = [m+½]\ \lambda$;

Examiners report

[N/A]

49b.

[3 marks]

Markscheme

number of fringes = $\frac{82}{1.2} = 68$;

fringe separation corresponds to a change in thickness of $\frac{\lambda}{2}$;

thickness of paper$= 68 \times \frac{590\times10^{-9}}{2} = 2.0 \times 10^{-5}\mathrm{m}$;

Examiners report

[N/A]