# R2019_49P1 *[60 marks]*

1. A particle moving in a circle completes 5 revolutions in 3 s. What is the frequency? *[1 mark]*

A. $\frac{3}{5}$Hz

B. $\frac{5}{3}$Hz

C. $\frac{3\pi}{5}$Hz

D. $\frac{5\pi}{3}$Hz

## Markscheme

B

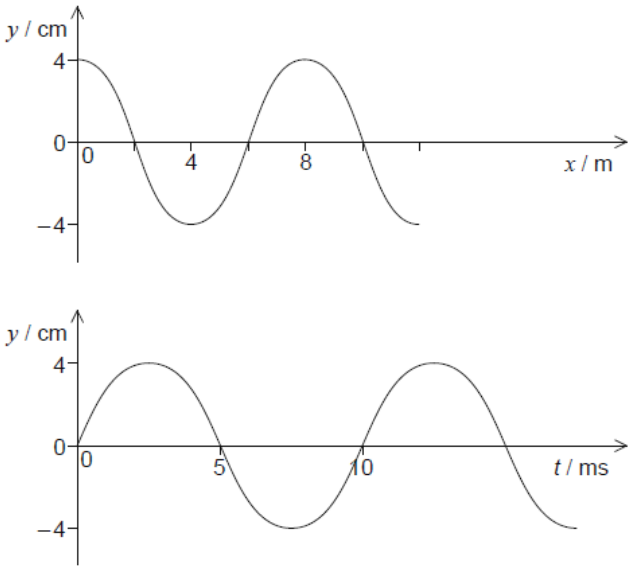
2. A longitudinal wave moves through a medium. Relative to the direction of energy transfer through the medium, what are the displacement of the medium and the direction of propagation of the wave? *[1 mark]*

| | Displacement of medium | Direction of propagation of wave |
|---|---|---|
| A. | parallel | perpendicular |
| B. | parallel | parallel |
| C. | perpendicular | parallel |
| D. | perpendicular | perpendicular |

## Markscheme

B

3. The graphs show the variation of the displacement $y$ of a medium with distance $x$ and with time $t$ for a travelling wave. *[1 mark]*




What is the speed of the wave?

A. $0.6\ \text{m s}^{-1}$

B. $0.8\ \text{m s}^{-1}$

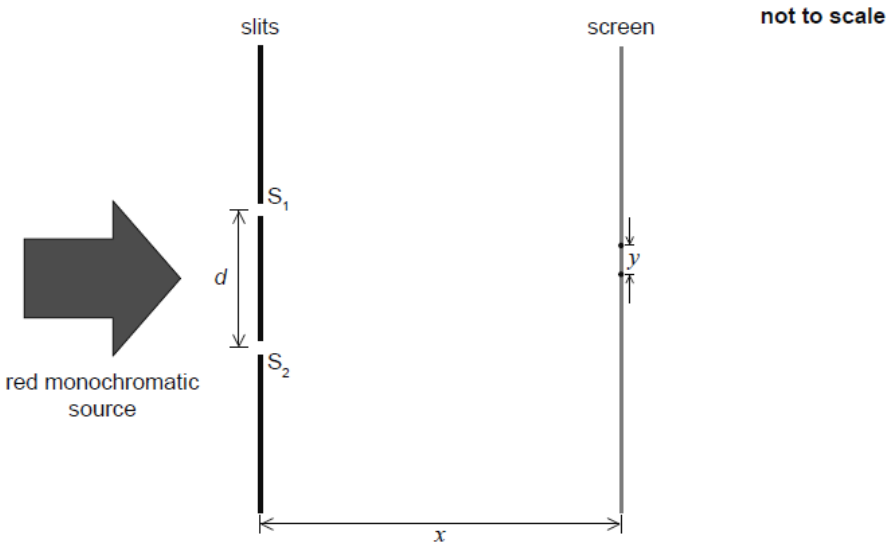
C. $600\ \text{m s}^{-1}$

D. $800\ \text{m s}^{-1}$

## Markscheme

D

4. In a double-slit experiment, a source of monochromatic red light is incident on slits $S_1$ and $S_2$ separated by a distance $d$. A screen is located at distance $x$ from the slits. A pattern with fringe spacing $y$ is observed on the screen. *[1 mark]*




Three changes are possible for this arrangement

I. increasing $x$

II. increasing $d$

III. using green monochromatic light instead of red.

Which changes will cause a decrease in fringe spacing $y$?

A. I and II only

B. I and III only

C. II and III only

D. I, II, and III

## Markscheme

C

5. Two strings of lengths $L_1$ and $L_2$ are fixed at both ends. The wavespeed is the same for both strings. They both vibrate at the same frequency. $L_1$ vibrates at its first harmonic. $L_2$ vibrates at its third harmonic. *[1 mark]*

What is $\frac{L_1}{L_2}$?

A. $\frac{1}{3}$

B. 1

C. 2

D. 3

## Markscheme

D

6. L is a point source of light. The intensity of the light at a distance 2 $x$ from L is *I*. What is the intensity at a distance 3$x$ from L? *[1 mark]*

A. $\frac{4}{9}I$

B. $\frac{2}{3}I$

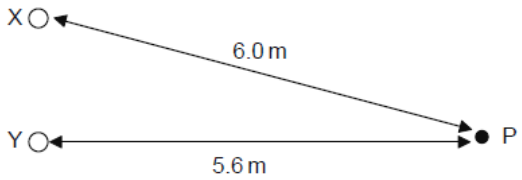
C. $\frac{3}{2}I$

D. $\frac{9}{4}I$

## Markscheme

A

7. X and Y are two coherent sources of waves. The phase difference between X and Y is zero. The intensity at P due to X and Y separately is *I*. The wavelength of each wave is 0.20 m. *[1 mark]*




What is the resultant intensity at P?

A. 0

B. *I*

C. 2*I*

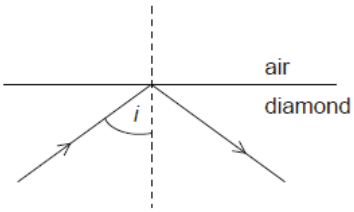
D. 4*I*

## Markscheme

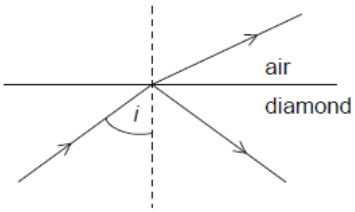
D

8. Light is incident at the boundary between air and diamond. The speed of light in diamond is less than the speed of light in air. The angle of incidence *i* of the light is greater than the critical angle. Which diagram is correct for this situation? *[1 mark]*

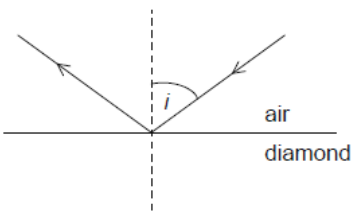
A.



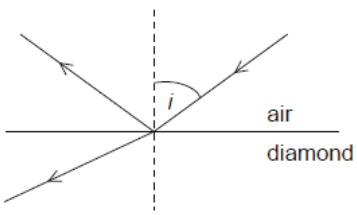

B.




C.




D.




## Markscheme

A

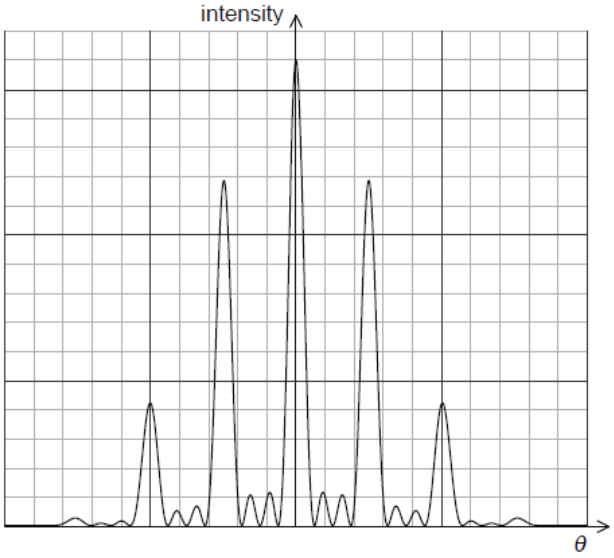
9. An object undergoing simple harmonic motion (SHM) has a period *T* and total energy *E*. The amplitude of oscillations is halved. What are the new period and total energy of the system? *[1 mark]*

| | Period | Total energy |
|---|---|---|
| A. | $\frac{T}{2}$ | $\frac{E}{4}$ |
| B. | $\frac{T}{2}$ | $\frac{E}{2}$ |
| C. | $T$ | $\frac{E}{4}$ |
| D. | $T$ | $\frac{E}{2}$ |

## Markscheme

C

10. The graph shows the variation with diffraction angle of the intensity of light when monochromatic light is incident on four slits. *[1 mark]*




The number of slits is increased keeping the width and the separation of the slits unchanged.

Three possible changes to the pattern are

I. the separation of the primary maxima increases

II. the intensity of the primary maxima increases

III. the width of the primary maxima decreases.

Which of the possible changes are correct?

A. I and II only

B. I and III only

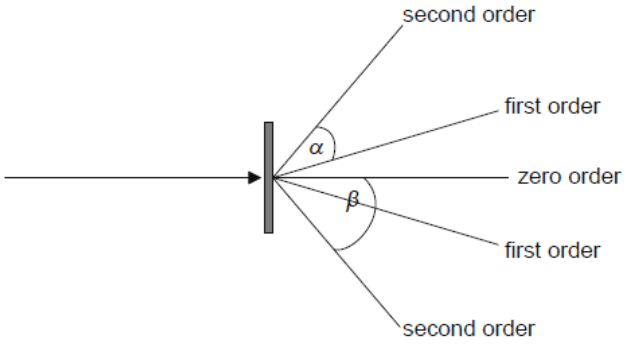
C. II and III only

D. I, II and III

# Markscheme

C

11. A beam of monochromatic light is incident normally on a diffraction grating. The grating spacing is *d*. The angles between the different orders are shown on the diagram. *[1 mark]*




What is the expression for the wavelength of light used?

A. $\frac{d \sin \alpha}{2}$

B. $\frac{d \sin \beta}{2}$

C. $d \sin \alpha$

D. $d \sin \beta$

## Markscheme

B

12. An ambulance siren emits a sound of frequency 1200 Hz. The speed of sound in air is 330 m $s^{-1}$. The ambulance moves towards a stationary observer at a constant speed of 40 m $s^{-1}$. What is the frequency heard by the observer? *[1 mark]*

A. $\frac{1200 \times 330}{370}$ Hz

B. $\frac{1200 \times 290}{330}$ Hz

C. $\frac{1200 \times 370}{330}$ Hz

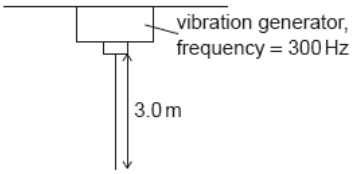
D. $\frac{1200 \times 330}{290}$ Hz

## Markscheme

D

13. A first-harmonic standing wave is formed on a vertical string of length 3.0 m using a vibration generator. The boundary conditions for this string are that it is fixed at one boundary and free at the other boundary. *[1 mark]*

**diagram not to scale**




The generator vibrates at a frequency of 300 Hz.

What is the speed of the wave on the string?

A. 0.90 km $s^{-1}$

B. 1.2 km $s^{-1}$

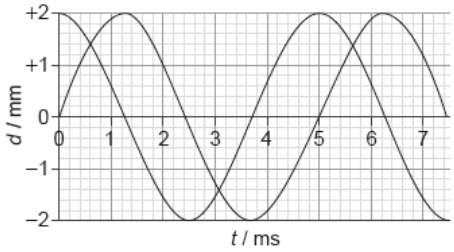
C. 1.8 km $s^{-1}$

D. 3.6 km $s^{-1}$

# Markscheme

D

14. Two travelling waves are moving through a medium. The diagram shows, for a point in the medium, the variation with time $t$ of the displacement $d$ of each of the waves. *[1 mark]*



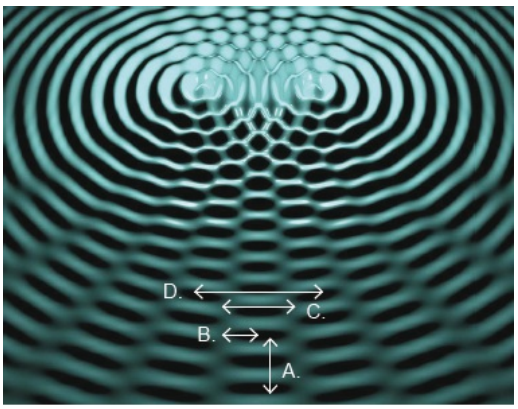

For the instant when $t$ = 2.0 ms, what is the phase difference between the waves and what is the resultant displacement of the waves?

| | Phase difference | Resultant displacement / mm |
|---|---|---|
| A. | 45° | −0.6 |
| B. | 90° | 2.6 |
| C. | 45° | 2.6 |
| D. | 90° | −0.6 |

# Markscheme

D

15. The diagram shows an interference pattern produced by two sources that oscillate on the surface of a liquid. *[1 mark]*




[Source: Science Photo Library www.sciencephoto.com]

Which of the distances shown in the diagram corresponds to **one** fringe width of the interference pattern?

## Markscheme

C

16. A system that is subject to a restoring force oscillates about an equilibrium position. *[1 mark]*

For the motion to be simple harmonic, the restoring force must be proportional to

A. the amplitude of the oscillation.

B. the displacement from the equilibrium position.

C. the potential energy of the system.

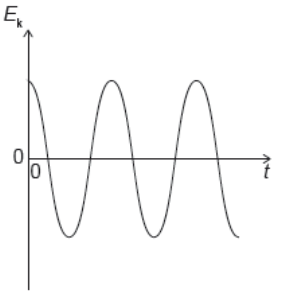
D. the period of the oscillation.

## Markscheme

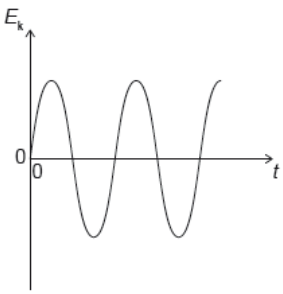
B

17. A particle is displaced from rest and released at time $t = 0$. It performs simple harmonic motion (SHM). Which graph shows the variation with time of the kinetic energy $E_k$ of the particle? *[1 mark]*

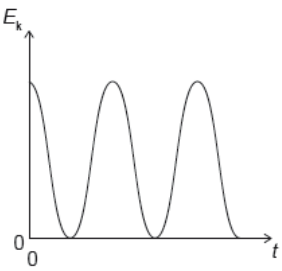
A.



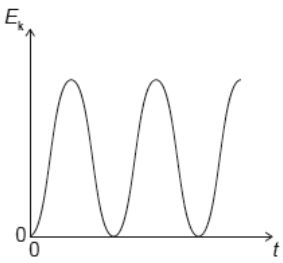

B.




C.




D.




## Markscheme

D

18. Two sound waves from a point source on the ground travel through the ground to a detector. The speed of one wave is 7.5 km $s^{-1}$, the speed of the other wave is 5.0 km $s^{-1}$. The waves arrive at the detector 15 s apart. What is the distance from the point source to the detector? *[1 mark]*

A. 38 km

B. 45 km

C. 113 km

D. 225 km

## Markscheme

D

19. What is true about the acceleration of a particle that is oscillating with simple harmonic motion (SHM)? *[1 mark]*

A. It is in the opposite direction to its velocity

B. It is decreasing when the potential energy is increasing

C. It is proportional to the frequency of the oscillation

D. It is at a minimum when the velocity is at a maximum

## Markscheme

D

20. What are the changes in the speed and in the wavelength of monochromatic light when the light passes from water to air? *[1 mark]*

| | Change in speed | Change in wavelength |
|---|---|---|
| A. | increases | increases |
| B. | increases | decreases |
| C. | decreases | increases |
| D. | decreases | decreases |

## Markscheme

A

21. A sound wave has a wavelength of 0.20 m. What is the phase difference between two points along the wave which are 0.85 m apart? *[1 mark]*

A. zero

B. 45°

C. 90°

D. 180°

## Markscheme

C

22. A pair of slits in a double slit experiment are illuminated with monochromatic light of wavelength 480 nm. The slits are separated by 1.0 mm. What is the separation of the fringes when observed at a distance of 2.0 m from the slits? *[1 mark]*

A. $2.4 \times 10^{-4}$ mm

B. $9.6 \times 10^{-4}$ mm

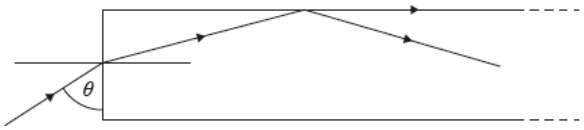
C. $2.4 \times 10^{-1}$ mm

D. $9.6 \times 10^{-1}$ mm

## Markscheme

D

23. A ray of light passes from the air into a long glass plate of refractive index $n$ at an angle $\theta$ to the edge of the plate. *[1 mark]*




The ray is incident on the internal surface of the glass plate and the refracted ray travels along the external surface of the plate.

What change to $n$ and what change to $\theta$ will cause the ray to travel entirely within the plate after incidence?

| | Change to $n$ | Change to $\theta$ |
|---|---|---|
| A. | increase | increase |
| B. | increase | decrease |
| C. | decrease | increase |
| D. | decrease | decrease |

## Markscheme

A

24. A mass at the end of a vertical spring and a simple pendulum perform oscillations on Earth that are simple harmonic with time period $T$. Both the pendulum and the mass-spring system are taken to the Moon. The acceleration of free fall on the Moon is smaller than that on Earth. What is correct about the time periods of the pendulum and the mass-spring system on the Moon? *[1 mark]*

| | Simple pendulum | Mass-spring system |
|---|---|---|
| A. | $T$ | $T$ |
| B. | greater than $T$ | $T$ |
| C. | greater than $T$ | greater than $T$ |
| D. | $T$ | greater than $T$ |

## Markscheme

B

25. Monochromatic light of wavelength λ in air is incident normally on a thin film of refractive index *n*. The film is surrounded by air. The intensity of the reflected light is a minimum. What is a possible thickness of the film? *[1 mark]*

A. $\frac{\lambda}{4n}$

B. $\frac{3\lambda}{4n}$

C. $\frac{\lambda}{n}$

D. $\frac{5\lambda}{4n}$

## Markscheme

C

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26. Monochromatic light is incident on 4 rectangular, parallel slits. The first principal maximum is observed at an angle $\theta$ to the direction of the incident light. The number of slits is increased to 8 each having the same width and spacing as the first 4. *[1 mark]*

Three statements about the first principal maximum with 8 slits are

I. the angle at which it is observed is greater than $\theta$

II. its intensity increases

III. its width decreases.

Which statements are correct?

A. I and II only

B. I and III only

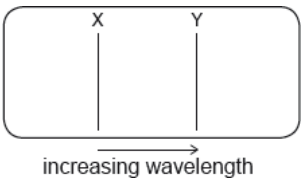
C. II and III only

D. I, II and III

## Markscheme

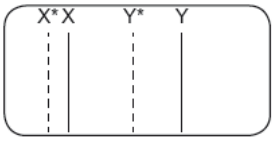
C

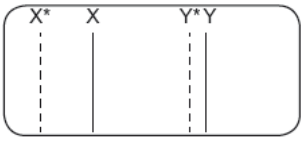
27. Two lines X and Y in the emission spectrum of hydrogen gas are measured by an observer stationary with respect to the gas sample. *[1 mark]*

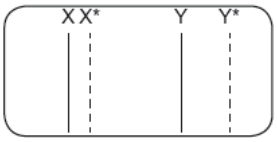


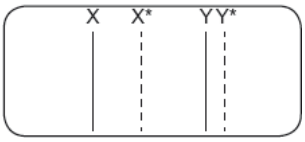

The emission spectrum is then measured by an observer moving away from the gas sample.

What are the correct shifts X* and Y* for spectral lines X and Y?

A.



B.



C.



D.



## Markscheme

C

28. A string stretched between two fixed points sounds its second harmonic at frequency *f*. *[1 mark]*

Which expression, where *n* is an integer, gives the frequencies of harmonics that have a node at the centre of the string?

A. $\frac{n+1}{2}f$

B. $nf$

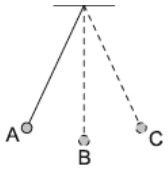
C. $2nf$

D. $(2n+1)f$

## Markscheme

B

29. A simple pendulum bob oscillates as shown. *[1 mark]*




At which position is the resultant force on the pendulum bob zero?

A. At position A

B. At position B

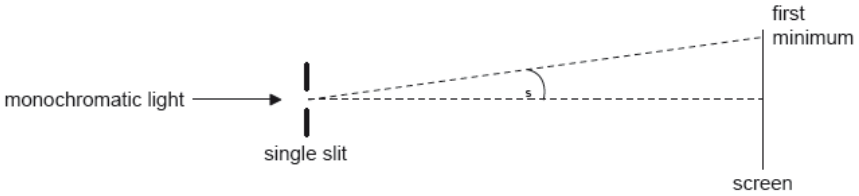
C. At position C

D. Resultant force is never zero during the oscillation

## Markscheme

D

30. A beam of monochromatic light is incident on a single slit and a diffraction pattern forms on the screen. *[1 mark]*




What change will increase $\theta_s$?

A. Increase the width of the slit

B. Decrease the width of the slit

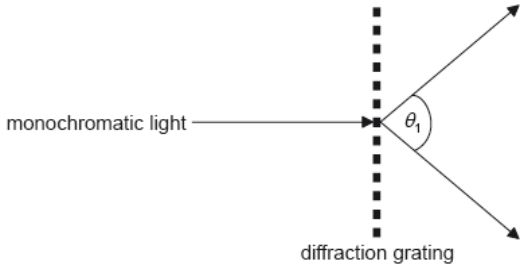
C. Increase the distance between the slit and the screen

D. Decrease the distance between the slit and the screen

## Markscheme

B

31. A beam of monochromatic light is incident on a diffraction grating of $N$ lines per unit length. The angle between the first orders is $\theta_1$. *[1 mark]*




What is the wavelength of the light?

A. $\frac{\sin\theta_1}{N}$

B. $N \sin \theta_1$

C. $N \sin\left(\frac{\theta_1}{2}\right)$

D. $\frac{\sin\left(\frac{\theta_1}{2}\right)}{N}$

## Markscheme

D

32. A train is approaching an observer with constant speed *[1 mark]*

$$\frac{c}{34}$$

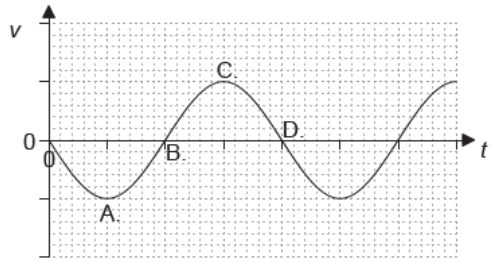
where $c$ is the speed of sound in still air. The train emits sound of wavelength $\lambda$. What is the observed speed of the sound and observed wavelength as the train approaches?

| | Speed of sound | Wavelength |
|---|---|---|
| A. | $c$ | $\frac{33\lambda}{34}$ |
| B. | $\frac{35c}{34}$ | $\frac{33\lambda}{34}$ |
| C. | $c$ | $\lambda$ |
| D. | $\frac{35c}{34}$ | $\lambda$ |

## Markscheme

A

33. The graph shows the variation with time $t$ of the velocity $v$ of an object undergoing simple harmonic motion (SHM). At which velocity does the displacement from the mean position take a maximum positive value? *[1 mark]*




## Markscheme

D

34. What is the phase difference, in rad, between the centre of a compression and the centre of a rarefaction for a longitudinal travelling wave? *[1 mark]*

A. 0

B. $\frac{\pi}{2}$

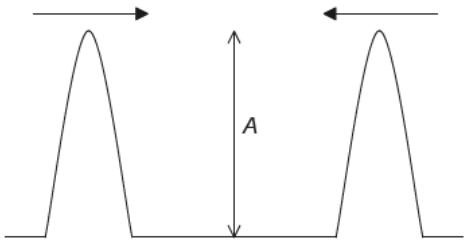
C. $\pi$

D. $2\pi$

## Markscheme

C

35. Two wave pulses, each of amplitude $A$, approach each other. They then superpose before continuing in their original directions. What is the total amplitude during superposition and the amplitudes of the individual pulses after superposition? *[1 mark]*




| | Total amplitude during superposition | Individual amplitudes after superposition |
|---|---|---|
| A. | $A$ | less than $A$ |
| B. | $A$ | $A$ |
| C. | $2A$ | less than $A$ |
| D. | $2A$ | $A$ |

## Markscheme

D

36. The refractive index for light travelling from medium X to medium Y is $\frac{4}{3}$. The refractive index for light travelling from medium Y to medium Z is $\frac{3}{5}$. What is the refractive index for light travelling from medium X to medium Z? *[1 mark]*

A. $\frac{4}{5}$

B. $\frac{15}{12}$

C. $\frac{5}{4}$

D. $\frac{29}{15}$

## Markscheme

A

37. A pipe of fixed length is closed at one end. What is $\frac{\text{third harmonic frequency of pipe}}{\text{first harmonic frequency of pipe}}$? *[1 mark]*

A. $\frac{1}{5}$

B. $\frac{1}{3}$

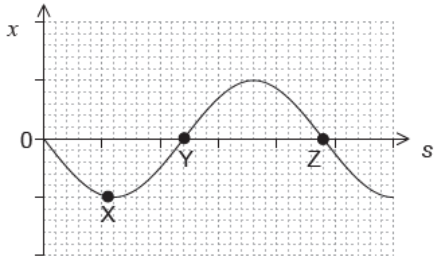
C. 3

D. 5

## Markscheme

C

38. The graph shows the variation with position $s$ of the displacement $x$ of a wave undergoing simple harmonic motion (SHM). *[1 mark]*



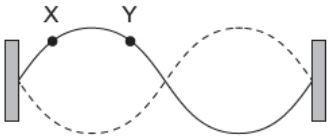

What is the magnitude of the velocity at the displacements X, Y and Z?

| | X | Y | Z |
|---|---|---|---|
| A. | maximum | zero | maximum |
| B. | zero | maximum | maximum |
| C. | maximum | maximum | zero |
| D. | zero | maximum | zero |

## Markscheme

B

39. The diagram shows a second harmonic standing wave on a string fixed at both ends. *[1 mark]*




What is the phase difference, in rad, between the particle at X and the particle at Y?

A. 0

B. $\frac{\pi}{4}$

C. $\frac{\pi}{2}$

D. $\frac{3\pi}{4}$

## Markscheme

A

40. A spring loaded with mass $m$ oscillates with simple harmonic motion. The amplitude of the motion is $A$ and the spring has total energy $E$. What is the total energy of the spring when the mass is increased to $3m$ and the amplitude is increased to $2A$? *[1 mark]*

A. $2E$

B. $4E$

C. $12E$

D. $18E$

## Markscheme

B

41. Monochromatic light is incident on two identical slits to produce an interference pattern on a screen. One slit is then covered so that no light emerges from it. What is the change to the pattern observed on the screen? *[1 mark]*

A. Fewer maxima will be observed.

B. The intensity of the central maximum will increase.

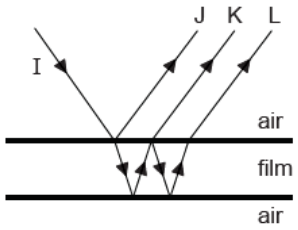
C. The outer maxima will become narrower.

D. The width of the central maximum will decrease.

## Markscheme

A

42. A transparent liquid forms a parallel-sided thin film in air. The diagram shows a ray I incident on the upper air–film boundary at normal incidence (the rays are shown at an angle to the normal for clarity). *[1 mark]*




Reflections from the top and bottom surfaces of the film result in three rays J, K and L. Which of the rays has undergone a phase change of $\pi$ rad?

A. J only

B. J and L only

C. J and K only

D. J, K and L

# Markscheme

A

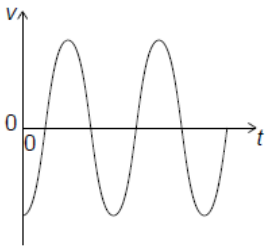
43. A stationary sound source emits waves of wavelength $\lambda$ and speed $v$. The source now moves away from a stationary observer. What are the wavelength and speed of the sound as measured by the observer? *[1 mark]*

| | Wavelength | Speed |
|---|---|---|
| A. | longer than $\lambda$ | equal to $v$ |
| B. | longer than $\lambda$ | less than $v$ |
| C. | shorter than $\lambda$ | equal to $v$ |
| D. | shorter than $\lambda$ | less than $v$ |

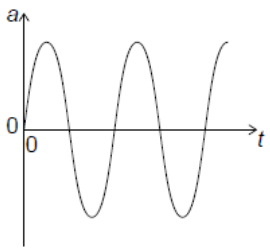
# Markscheme

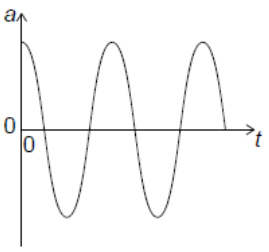
A

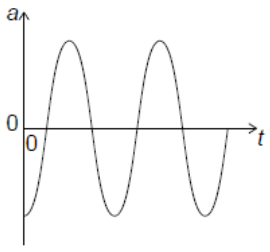
44. A particle undergoes simple harmonic motion (SHM). The graph shows the variation of velocity $v$ of the particle with time $t$. *[1 mark]*

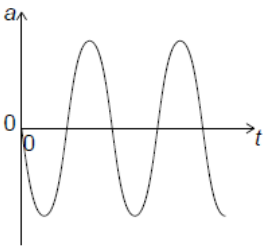



What is the variation with time of the acceleration $a$ of the particle?

A.



B.



C.



D.


## Markscheme

A

45. What statement about X-rays and ultraviolet radiation is correct? *[1 mark]*

A. X-rays travel faster in a vacuum than ultraviolet waves.

B. X-rays have a higher frequency than ultraviolet waves.

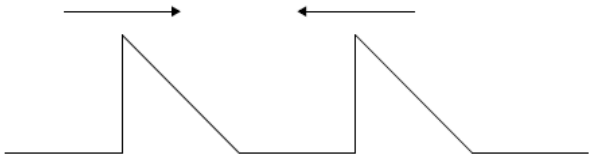
C. X-rays cannot be diffracted unlike ultraviolet waves.

D. Microwaves lie between X-rays and ultraviolet in the electromagnetic spectrum.

## Markscheme

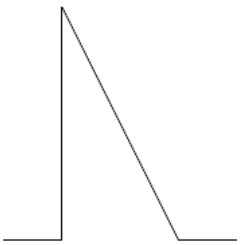
B

46. Two pulses are travelling towards each other. *[1 mark]*

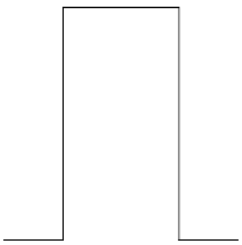


What is a possible pulse shape when the pulses overlap?

A.



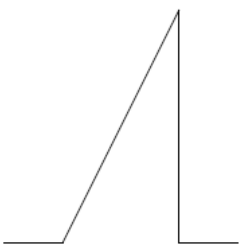
B.



C.



D.



## Markscheme

A

47. Unpolarized light of intensity $I_0$ is incident on the first of two polarizing sheets. Initially the planes of polarization of the sheets are perpendicular. *[1 mark]*

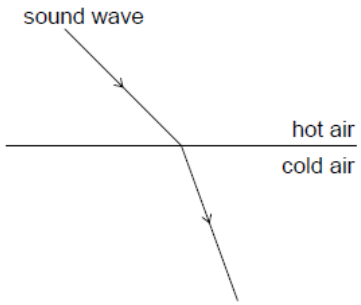
Which sheet must be rotated and by what angle so that light of intensity $\frac{I_0}{4}$ can emerge from the second sheet?

| | Rotated sheet | Angle of rotation |
|---|---|---|
| A. | 1 only | $\cos^{-1}\frac{\sqrt{2}}{2}$ |
| B. | 2 only | $\cos^{-1}\frac{1}{2}$ |
| C. | 1 or 2 | $\cos^{-1}\frac{\sqrt{2}}{2}$ |
| D. | 1 or 2 | $\cos^{-1}\frac{1}{2}$ |

## Markscheme

C

48. When a sound wave travels from a region of hot air to a region of cold air, it refracts as shown. *[1 mark]*




What changes occur in the frequency and wavelength of the sound as it passes from the hot air to the cold air?

| | Frequency | Wavelength |
|---|---|---|
| A. | unchanged | increases |
| B. | unchanged | decreases |
| C. | increases | increases |
| D. | decreases | decreases |

## Markscheme

B

49. In simple harmonic oscillations which two quantities always have opposite directions? *[1 mark]*

A. Kinetic energy and potential energy

B. Velocity and acceleration

C. Velocity and displacement

D. Acceleration and displacement

## Markscheme

D

50. A girl in a stationary boat observes that 10 wave crests pass the boat every minute. What is the period of the water waves? *[1 mark]*

A. $\frac{1}{10}$ min

B. $\frac{1}{10}$ $\text{min}^{-1}$

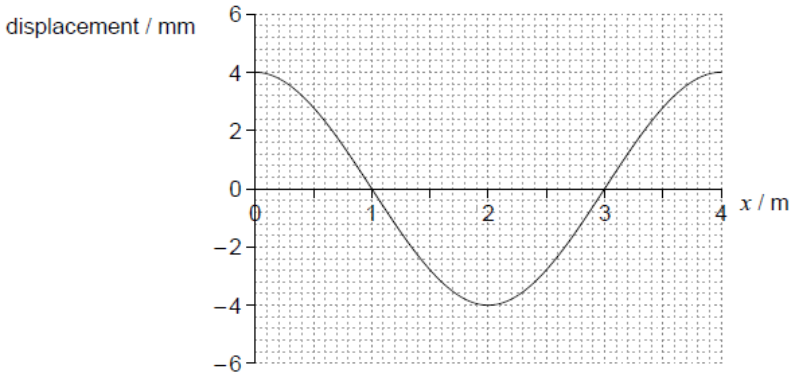
C. 10 min

D. 10 $\text{min}^{-1}$

## Markscheme

A

51. The graph shows the variation with distance $x$ of the displacement of the particles of a medium in which a longitudinal wave is travelling from left to right. Displacements to the right of equilibrium positions are positive. *[1 mark]*




Which point is at the centre of a compression?

A. $x = 0$

B. $x = 1$ m

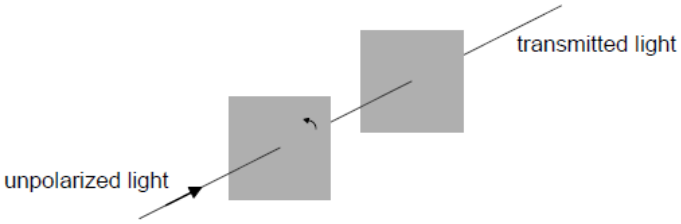
C. $x = 2$ m

D. $x = 3$ m

## Markscheme

B

52. A beam of unpolarized light is incident on the first of two parallel polarizers. The transmission axes of the two polarizers are initially parallel. *[1 mark]*




The first polarizer is now rotated about the direction of the incident beam by an angle smaller than 90°. Which gives the changes, if any, in the intensity and polarization of the transmitted light?

| | Intensity | Polarization |
|---|---|---|
| A. | different | no change |
| B. | different | different |
| C. | no change | no change |
| D. | no change | different |

## Markscheme

A

53. The frequency of the first harmonic standing wave in a pipe that is open at both ends is 200 Hz. What is the frequency of the first harmonic in a pipe of the same length that is open at one end and closed at the other? *[1 mark]*

A. 50 Hz

B. 75 Hz

C. 100 Hz

D. 400 Hz

## Markscheme

C

54. A travelling wave of period 5.0 ms travels along a stretched string at a speed of 40 m s $^{-1}$. Two points on the string are 0.050 m apart. *[1 mark]*

What is the phase difference between the two points?

A. 0

B. $\frac{\pi}{2}$

C. $\pi$

D. $2\pi$

## Markscheme

B

55. Properties of waves are *[1 mark]*

I. polarization
II. diffraction
III. refraction

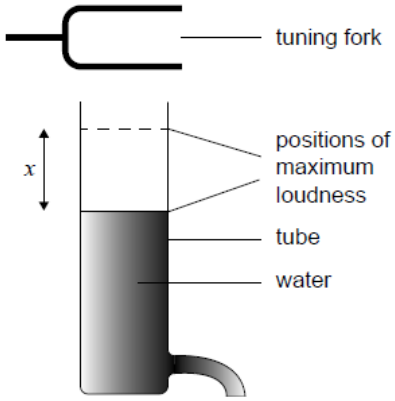
Which of these properties apply to sound waves?

A. I and II
B. I and III
C. II and III
D. I, II and III

## Markscheme

C

56. Water is draining from a vertical tube that was initially full. A vibrating tuning fork is held near the top of the tube. For two positions of the water surface only, the sound is at its maximum loudness. *[1 mark]*




The distance between the two positions of maximum loudness is $x$.

What is the wavelength of the sound emitted by the tuning fork?

A. $\frac{x}{2}$

B. $x$

C. $\frac{3x}{2}$

D. $2x$

## Markscheme

D

57. A pendulum oscillating near the surface of the Earth swings with a time period $T$. What is the time period of the same pendulum near the surface of the planet Mercury where the gravitational field strength is $0.4g$? *[1 mark]*

A. $0.4T$

B. $0.6T$

C. $1.6T$

D. $2.5T$

## Markscheme

C

58. For fringes to be observed in a double-slit interference experiment, the slits must emit waves that are coherent. *[1 mark]*

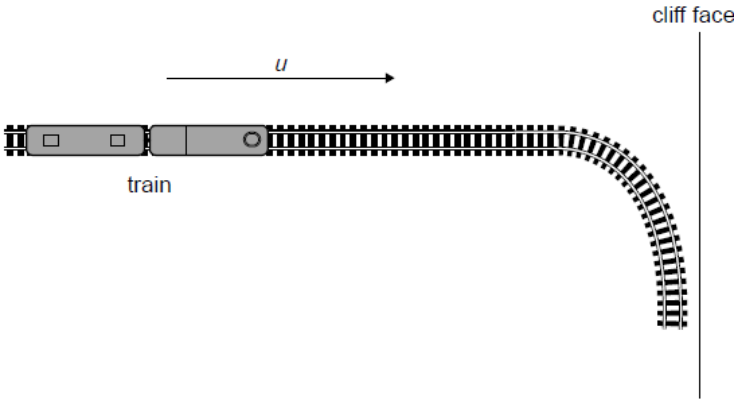
What conditions are required for the frequency of the waves and for the phase difference between the waves so that the waves are coherent?

| | Frequency of waves | Phase difference between waves |
|---|---|---|
| A. | same | variable |
| B. | same | constant |
| C. | constant difference | variable |
| D. | constant difference | constant |

## Markscheme

B

59. A train moving at speed *u* relative to the ground, sounds a whistle of constant frequency *f* as it moves towards a vertical cliff face. *[1 mark]*




The sound from the whistle reaches the cliff face and is reflected back to the train. The speed of sound in stationary air is *c*.

What whistle frequency is observed on the train after the reflection?

A. $\frac{(c+u)}{(c-u)}f$

B. (c + u) *f*

C. (c – u) *f*

D. $\frac{(c-u)}{(c+u)}f$

## Markscheme

A

60. A mass oscillates with simple harmonic motion (SHM) of amplitude $x_0$. Its total energy is 16 J. *[1 mark]*

What is the kinetic energy of the mass when its displacement is $\frac{x_0}{2}$?

A. 4 J

B. 8 J

C. 12 J

D. 16 J

## Markscheme

C