1. The period of a particle undergoing simple harmonic motion (SHM) is \( T \). The ratio \( \frac{\text{acceleration of the particle}}{\text{displacement of the particle from its equilibrium position}} \) is proportional to \( T^{-2} \).

A. \( T^{-2} \)
B. \( T^{-1} \)
C. \( T \)
D. \( T^2 \)

Markscheme

A

Examiners report

[N/A]

2. A particle of mass \( m \) oscillates with simple harmonic motion (SHM) of angular frequency \( \omega \). The amplitude of the SHM is \( A \). What is the kinetic energy of the particle when it is half way between the equilibrium position and one extreme of the motion?

A. \( \frac{1}{4}ma^2 \)
B. \( \frac{3}{8}ma^2 \)
C. \( \frac{9}{32}ma^2 \)
D. \( \frac{11}{32}ma^2 \)

Markscheme

B

Examiners report

[N/A]

3. A source emits sound of wavelength \( \lambda_0 \) and wave speed \( v_0 \). A stationary observer hears the sound as the source moves away. What are the wavelength of the sound and the wave speed of the sound as measured by the stationary observer?

<table>
<thead>
<tr>
<th></th>
<th>Wavelength</th>
<th>Wave speed</th>
</tr>
</thead>
<tbody>
<tr>
<td>A.</td>
<td>less than ( \lambda_0 )</td>
<td>equal to ( v_0 )</td>
</tr>
<tr>
<td>B.</td>
<td>greater than ( \lambda_0 )</td>
<td>equal to ( v_0 )</td>
</tr>
<tr>
<td>C.</td>
<td>less than ( \lambda_0 )</td>
<td>less than ( v_0 )</td>
</tr>
<tr>
<td>D.</td>
<td>greater than ( \lambda_0 )</td>
<td>less than ( v_0 )</td>
</tr>
</tbody>
</table>

Markscheme

B
4. A radio telescope has a circular collecting dish of diameter 5.0 m. It is used to observe two distant galaxies that are both emitting electromagnetic radiation of wavelength 20 cm. The images of the galaxies are just resolved by the telescope. What is the angle subtended by the galaxies at the telescope?

A. 0.05 rad  
B. 0.3 rad  
C. 5 rad  
D. 30 rad

**Markscheme**

A

**Examiners report**

[N/A]

5. The bob of a pendulum has an initial displacement $x_0$ to the right. The bob is released and allowed to oscillate. The graph shows how the displacement varies with time. At which point is the velocity of the bob at maximum towards the right?

**Markscheme**

A

**Examiners report**

[N/A]
A car horn emits sound of frequency $f$. While the horn is sounding, the car moves in a straight line towards a stationary observer. \[1 \text{ mark}\]
The speed of the car is $0.10v$ where $v$ is the speed of sound. What is the frequency of the sound of the horn heard by the observer?

A. $\dfrac{f}{0.30}$  
B. $1.1f$  
C. $\dfrac{f}{1.1}$  
D. $0.90f$

**Markscheme**

A

**Examiners report**

[N/A]

The graph below shows the variation of the intensity of light with angle for the diffraction pattern produced when light is diffracted by a slit.

According to the Rayleigh criterion, when the diffraction patterns of two slits are just resolved

A. the first maximum of one diffraction pattern coincides with the central maximum of the other diffraction pattern.
B. the central maximum of one diffraction pattern coincides with the central maximum of the other diffraction pattern.
C. the first minimum of one diffraction pattern coincides with the central maximum of the other diffraction pattern.
D. the first minimum of one diffraction pattern coincides with the first minimum of the other diffraction pattern.

**Markscheme**

C

**Examiners report**

[N/A]
8. An object emitting a sound of frequency 100 Hz orbits in a horizontal circle at a rate of two revolutions per second.

An observer standing a short distance away from the object is able to hear the sound. Which of the following describes the sound the observer is able to hear?

A. A sound of constant frequency but varying in amplitude
B. A sound of constantly varying frequency
C. A sound with a frequency of 50 Hz
D. A sound with a frequency of 200 Hz

Markscheme
B

Examiners report
[N/A]

9. Green light is emitted by two point sources. The light passes through a narrow slit and is received by an observer. The images of the two sources just fail to be resolved. Which change allows for the images to be resolved?

A. Replacing the narrow slit with a circular aperture of same size.
B. Moving the two sources further from the aperture.
C. Using red light.
D. Using violet light.

Markscheme
D

Examiners report
[N/A]

10. A particle undergoes simple harmonic motion (SHM) of maximum kinetic energy $E_{\text{max}}$ and amplitude $x_0$. The particle is released from rest at its maximum displacement amplitude.

What is the change in the kinetic energy when the particle has travelled a distance of $\frac{\pi}{3}$?

A. $\frac{E_{\text{max}}}{9}$
B. $\frac{4E_{\text{max}}}{9}$
C. $\frac{5E_{\text{max}}}{9}$
D. $\frac{8E_{\text{max}}}{9}$
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 $x/3$ then its distance to the equilibrium position is $2x/3$. Substituting this value into the relevant equation in the Data Booklet gives response C directly.

11. A body moves with simple harmonic motion (SHM) with period $T$ and total energy $E_T$. What is the total energy when the period of the motion is changed to $5T$ and the amplitude of the motion remains constant?

A. $0.04 \, E_T$
B. $0.2 \, E_T$
C. $5 \, E_T$
D. $25 \, E_T$

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 $x/3$ then its distance to the equilibrium position is $2x/3$. Substituting this value into the relevant equation in the Data Booklet gives response C directly.

12. A source of sound moves away from an observer. The observed frequency of the sound differs from the frequency emitted by the source because the

A. observed wavelength of the sound is less than the emitted wavelength.
B. observed wavelength of the sound is greater than the emitted wavelength.
C. speed of sound relative to the observer has decreased.
D. speed of sound relative to the observer has increased.

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 $x/3$ then its distance to the equilibrium position is $2x/3$. Substituting this value into the relevant equation in the Data Booklet gives response C directly.
Radiation is incident on a single rectangular slit. The diffracted beam that emerges from the slit is incident on a screen. The slit width is then doubled and the wavelength of the radiation is also doubled. The intensity of the radiation remains the same.

Which of the following correctly describes the angular width of the central maximum of the diffracted beam and the total number of photons incident every second on the screen?

<table>
<thead>
<tr>
<th>Angular width of the central maximum</th>
<th>Number of photons incident every second on the screen</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. unchanged</td>
<td>unchanged</td>
</tr>
<tr>
<td>B. changed</td>
<td>unchanged</td>
</tr>
<tr>
<td>C. unchanged</td>
<td>changed</td>
</tr>
<tr>
<td>D. changed</td>
<td>changed</td>
</tr>
</tbody>
</table>

**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.

A small point mass \( m \) is placed at the same distance from two identical fixed spherical masses far from any other masses.

The point mass is released from rest. The point mass will

A. move upwards.
B. stay where it is.
C. move towards \( P \) and stop there.
D. oscillate about point \( P \).
A particle P executes simple harmonic motion (SHM) about its equilibrium position Y. The amplitude of the motion is XY.

At which of the positions shown on the diagram is the acceleration of P equal to zero and the kinetic energy of P equal to zero?

<table>
<thead>
<tr>
<th>Acceleration</th>
<th>Kinetic energy</th>
</tr>
</thead>
<tbody>
<tr>
<td>A.</td>
<td>Y</td>
</tr>
<tr>
<td>B.</td>
<td>X</td>
</tr>
<tr>
<td>C.</td>
<td>Y</td>
</tr>
<tr>
<td>D.</td>
<td>X</td>
</tr>
</tbody>
</table>

The amplitude of the motion is XY.

At which of the positions shown on the diagram is the acceleration of P equal to zero and the kinetic energy of P equal to zero?

[1 mark]

Markscheme
A

Examiners report
[N/A]
A particle executes simple harmonic motion (SHM) with period $T$.

Which sketch graph correctly shows how the total energy $E$ of the particle varies with time $t$ from $t = 0$ to $t = \frac{T}{2}$?

**Markscheme**

D

**Examiners report**

[N/A]
17. Light of wavelength $\lambda_0$ is emitted from a nearby galaxy. The light is received on Earth and the wavelength is measured to be $\lambda$ where $\lambda < \lambda_0$. Which of the following correctly describes the speed and direction of motion of the galaxy?

<table>
<thead>
<tr>
<th>Speed</th>
<th>Direction</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\frac{\lambda_0 - \lambda}{\lambda_0} c$</td>
<td>towards earth</td>
</tr>
<tr>
<td>$\frac{\lambda_0 - \lambda}{\lambda} c$</td>
<td>towards earth</td>
</tr>
<tr>
<td>$\frac{\lambda_0 - \lambda}{\lambda_0} c$</td>
<td>away from earth</td>
</tr>
<tr>
<td>$\frac{\lambda_0 - \lambda}{\lambda} c$</td>
<td>away from earth</td>
</tr>
</tbody>
</table>

**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.

18. The diagram shows a train travelling in a straight line at constant speed $v$, as it approaches the platform of a station.

The whistle of the engine is emitting a sound of constant frequency. Which of the following is not true for the sound of the whistle heard by an observer on the platform?

A. A sudden change in frequency of the sound as the train passes the observer.
B. A sound of constant frequency as the train approaches the observer.
C. A sound of increasing frequency as the train approaches the observer and of decreasing frequency after the train has passed the observer.
D. A sound of constant frequency after the train has passed the observer.
A parallel beam of coherent light of wavelength $\lambda$ is incident on a rectangular slit of width $d$. After passing through the slit the light is incident on a screen a distance $D$ from the slit where $D$ is much greater than $d$. What is the width of the central maximum of the diffraction pattern as measured on the screen?

A. $\frac{2D\lambda}{d}$
B. $\frac{2\lambda}{D}$
C. $\frac{\pi\lambda}{D}$
D. $\frac{d}{2\lambda}$

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.
An ambulance emits a sound of frequency $f$ as it travels along a straight road between stationary observers A and B.

Which of the following shows how the frequency of the sound heard by each observer compares with $f$?

<table>
<thead>
<tr>
<th>Observer A</th>
<th>Observer B</th>
</tr>
</thead>
<tbody>
<tr>
<td>greater than $f$</td>
<td>greater than $f$</td>
</tr>
<tr>
<td>greater than $f$</td>
<td>less than $f$</td>
</tr>
<tr>
<td>less than $f$</td>
<td>greater than $f$</td>
</tr>
<tr>
<td>less than $f$</td>
<td>less than $f$</td>
</tr>
</tbody>
</table>

**Markscheme**

C

**Examiners report**

[N/A]
The intensity distribution of monochromatic light passing through a narrow slit and then incident on a screen is shown below.

When the slit width is reduced which diagram shows the new intensity distribution? Diagrams are drawn to the same scale as the original.

A. 

B. 

C. 

D. 

**Markscheme**

B

**Examiners report**

[N/A]
22. Which graph shows how velocity $v$ varies with displacement $x$ of a system moving with simple harmonic motion? [1 mark]

![Graphs A, B, C, D showing velocity vs. displacement for simple harmonic motion]

**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.

23. An object undergoes simple harmonic motion with time period $T$ and amplitude 0.5 m. At time $t = 0$ s the displacement of the object is a maximum. What is the displacement of the object at time $t = \frac{3T}{4}$? [1 mark]

A. -0.50 m  
B. 0.50 m  
C. 0.25 m  
D. 0 m

**Markscheme**
D

**Examiners report**
[N/A]
A sample of hydrogen on Earth emits a spectral line that is measured by an Earth observer to have wavelength 500 nm. The same spectral line is emitted by a galactic source that is moving away from Earth at speed of 0.1c. What is the wavelength of the galactic spectral line that will be measured by the Earth observer?

A. 50 nm  
B. 450 nm  
C. 550 nm  
D. 5000 nm

Markscheme
C

Examiners report
[N/A]
A parallel beam of monochromatic light of wavelength $\lambda$ passes through a slit of width $b$ and forms a diffraction pattern on a screen far from the slit. The angle at which the first diffraction minimum is formed is $\theta$.

Which of the following changes in $\lambda$ and $b$, carried out separately, will increase the value of $\theta$?

<table>
<thead>
<tr>
<th></th>
<th>$\lambda$</th>
<th>$b$</th>
</tr>
</thead>
<tbody>
<tr>
<td>A.</td>
<td>decrease</td>
<td>increase</td>
</tr>
<tr>
<td>B.</td>
<td>increase</td>
<td>increase</td>
</tr>
<tr>
<td>C.</td>
<td>decrease</td>
<td>decrease</td>
</tr>
<tr>
<td>D.</td>
<td>increase</td>
<td>decrease</td>
</tr>
</tbody>
</table>

**Markscheme**

D
26. Two coloured point sources are observed through an optical telescope. Which of the following colours for the sources would best allow their images to be resolved? [1 mark]

A. Blue  
B. Green  
C. Red  
D. Yellow

**Markscheme**  
A

**Examiners report**  
[N/A]

27. A stationary source of sound emits sound of frequency $f$. A moving observer measures the sound as having the frequency $f'$. The observer is moving directly away from the source at a speed that is 30% of the speed of sound in air. Which of the following gives the correct value for $f'$? [1 mark]

$$\frac{7}{10}$$  
$$\frac{10}{13}$$  
$$\frac{13}{10}$$  
$$\frac{10}{7}$$

**Markscheme**  
A

**Examiners report**  
[N/A]
An optical instrument is used to observe an object illuminated with monochromatic light. Which of the following changes to the frequency of the light and to the aperture diameter of the optical instrument will increase the resolution of the image of the object formed by the instrument?

<table>
<thead>
<tr>
<th>Frequency</th>
<th>Aperture diameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>A.</td>
<td>increase</td>
</tr>
<tr>
<td>B.</td>
<td>decrease</td>
</tr>
<tr>
<td>C.</td>
<td>increase</td>
</tr>
<tr>
<td>D.</td>
<td>decrease</td>
</tr>
</tbody>
</table>

**Markscheme**

C

**Examiners report**

[N/A]

An object undergoes simple harmonic motion. Which graph shows the relationship between the acceleration \( a \) and the displacement \( x \) from the equilibrium position?

A. ![Graph A](image)

B. ![Graph B](image)

C. ![Graph C](image)

D. ![Graph D](image)

**Markscheme**

A
30. An object undergoes simple harmonic motion. Which graph shows the relationship between the acceleration $a$ and the displacement $x$ from the equilibrium position?

A.  

B.  

C.  

D.  

**Markscheme**  
A

**Examiners report**  
[N/A]

31. A siren on an ambulance emits sound of frequency $f$. The speed of sound in still air is $v$. What is the frequency of the sound observed when the ambulance travels at speed $\frac{v}{10}$ towards a stationary observer?  

A. $\frac{f}{10}$  
B. $f$  
C. $\frac{11}{10}f$  
D. $\frac{11}{9}f$

**Markscheme**  
D
32. An object is undergoing simple harmonic motion (SHM) about a fixed point P. The magnitude of its displacement from P is $x$. Which of the following is correct?

<table>
<thead>
<tr>
<th>Magnitude of resultant force</th>
<th>Direction of resultant force</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. proportional to $x$</td>
<td>towards P</td>
</tr>
<tr>
<td>B. inversely proportional to $x$</td>
<td>towards P</td>
</tr>
<tr>
<td>C. proportional to $x$</td>
<td>away from P</td>
</tr>
<tr>
<td>D. inversely proportional to $x$</td>
<td>away from P</td>
</tr>
</tbody>
</table>

**Markscheme**

A

**Examiners report**

[N/A]

33. An object undergoes simple harmonic motion (SHM). The total energy of the object is proportional to

A. the amplitude of the oscillations.
B. the time period of the oscillations.
C. the frequency of the oscillations.
D. the mass of the object.

**Markscheme**

D

**Examiners report**

[N/A]

34. A particle undergoing simple harmonic motion (SHM) oscillates with time period $T$ and angular frequency $\omega$. The time period of the SHM changes to $2T$. Which of the following gives the new value of $\omega$?

A. $\frac{\omega}{2}$
B. $\frac{\omega}{4}$
C. $2\omega$
D. $4\omega$
A particle is undergoing simple harmonic motion (SHM) in a horizontal plane. The total mechanical energy of the system is $E$. Which of the following correctly gives the kinetic energy of the particle at the positions of maximum displacement and equilibrium?

<table>
<thead>
<tr>
<th>Maximum displacement</th>
<th>Equilibrium</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. $\frac{1}{2}E$</td>
<td>$\frac{1}{2}E$</td>
</tr>
<tr>
<td>B. 0</td>
<td>$E$</td>
</tr>
<tr>
<td>C. $\frac{1}{2}E$</td>
<td>0</td>
</tr>
<tr>
<td>D. $E$</td>
<td>0</td>
</tr>
</tbody>
</table>

Which of the following would be diffracted the most when incident on a slit of width 1 cm?

A. microwaves
B. red light
C. ultraviolet
D. X-rays

Which of the following would be diffracted the most when incident on a slit of width 1 cm? [1 mark]

A.
37. Two point sources of light have an angular separation of $\theta$, as measured by a distant observer. The light passes through a circular aperture of radius $r$ just before reaching the observer. Which of the following conditions must be true for the two sources to be resolved?

A. $\theta < \frac{1}{2} \frac{\lambda}{r}$
B. $\theta < \frac{1}{2} \frac{\lambda}{r}$
C. $\theta \geq \frac{1}{2} \frac{\lambda}{r}$
D. $\theta \geq \frac{1}{2} \frac{\lambda}{r}$

**Markscheme**

D

**Examiners report**

[N/A]

38. A point source of sound is moving to the right at constant speed. The source emits sound waves of constant frequency. The speed of the source is less than the speed of sound. Which diagram correctly shows the wavefronts of the sound?

A.  

![Diagram A]

B.  

![Diagram B]

C.  

![Diagram C]

D.  

![Diagram D]

**Markscheme**

A

**Examiners report**

[N/A]
A coherent beam of light of wavelength $\lambda$ is incident on a double slit. The width of the slits is small compared to their separation. An interference pattern is observed on a distant screen. O is the mid point of the screen.

There is a bright fringe at O and a bright fringe at P. Between O and P there are three dark fringes.

Which of the following is the path difference between the light from the two slits arriving at P?

- A. $1.5 \lambda$
- B. $2 \lambda$
- C. $3 \lambda$
- D. $4 \lambda$

**Markscheme**

C

**Examiners report**

Young's double slit experiment is not explicitly on the syllabus. But candidates are expected to study the condition for constructive interference in terms of the path difference (4.5.6). This question was deemed fair and it was pleasing to see how many candidates chose the correct response.

An object to be viewed by a microscope is irradiated with blue light. The reason for using blue light rather than light of a longer wavelength is to increase

- A. diffraction.
- B. interference.
- C. resolution.
- D. magnification.

**Markscheme**

C

**Examiners report**

[N/A]