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Level 2 Physics, 2015

91170 Demonstrate understanding of waves

9.30 a.m. Tuesday 17 November 2015
Credits: Four

Achievement	Achievement with Merit	Achievement with Excellence
Demonstrate understanding of waves.	Demonstrate in-depth understanding of waves.	Demonstrate comprehensive understanding of waves.

Check that the National Student Number (NSN) on your admission slip is the same as the number at the top of this page.

You should attempt ALL the questions in this booklet.

Make sure that you have Resource Sheet L2–PHYSR.

In your answers use clear numerical working, words and/or diagrams as required.

Numerical answers should be given with an appropriate SI unit.

If you need more space for any answer, use the page(s) provided at the back of this booklet and clearly number the question.

Check that this booklet has pages 2–12 in the correct order and that none of these pages is blank.

YOU MUST HAND THIS BOOKLET TO THE SUPERVISOR AT THE END OF THE EXAMINATION.

Excellence

TOTAL 32

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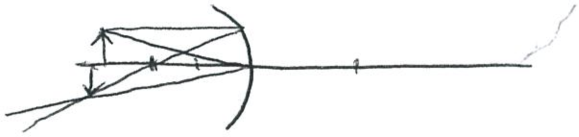

QUESTION ONE: MIRRORS

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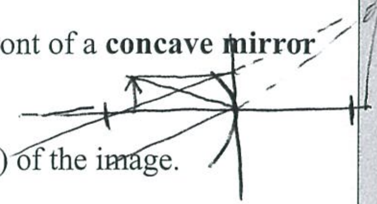
Sela is experimenting with curved mirrors. She places a lighted candle in front of a **concave mirror** and obtains an image on a screen.



(a) State the nature (real or virtual) and the orientation (upright or inverted) of the image.

Real, inverted

Both correct

a

(b) The image of the candle is formed 25.0 cm from the mirror. The focal length of the mirror is 16.0 cm. The height of the image is 0.50 cm.

Calculate the **distance** of the object from the mirror and the **height** of the object. concave pos f.

Di = 25 f = 16 hi = 0.50

$\frac{1}{f} = \frac{1}{Di} + \frac{1}{Do}$

$1/16 = \frac{1}{25} + \frac{1}{Do}$ ~~Do =~~

$1/16 - 1/25 = 1/Do$ Do = 44 cm away from mirror

$\frac{Di}{Do} = \frac{Hi}{Ho}$ $\frac{25}{44} = \frac{0.50}{Ho}$ Ho = 0.88cm

Both calculations correct

m

(c) Sela then placed the candle in front of a **convex mirror**.

Explain why she was unable to get an image of the candle on a screen.

A convex mirror will always form an upright, diminished and virtual image. Virtual images are not able to be projected onto a screen as they are not formed with real light rays (instead they are formed with virtual rays) which cannot be projected onto a screen so Sela will not be able to get an image of the candle on the screen with the convex mirror.

m

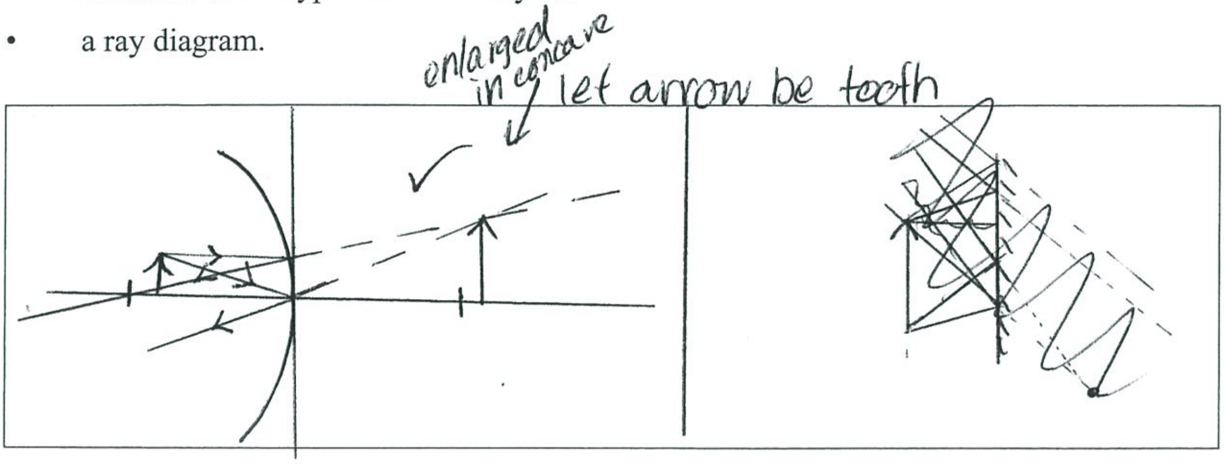
Complete explanation

(d) Dentists use curved mirrors.

Write a comprehensive explanation for why dentists use curved mirrors instead of plane mirrors to examine a tooth.

In your answer include:

- the name of the type of mirror they use
- a ray diagram.



Dentists will use concave mirrors to examine a tooth because the concave mirror will give them an enlarged view of the tooth if the mirror is placed close to the tooth so that the distance between the mirror and tooth is smaller than the distance of the focal point. They will not use a plane mirror which would only give them an image of the tooth, which is the same size as the tooth itself. Plane mirrors also give a laterally inverted image, which is not beneficial to dentists who want an image that is the right way as they ~~want~~ perceive it to be.

Correct diagram AND a full explanation of why and how a concave mirror could be used and why a plane mirror may not be used.

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e

E8

QUESTION TWO: LENSES AND REFRACTION

ASSESSOR'S USE ONLY

(a) Tom uses a convex lens as a magnifying glass. He puts a petal of a flower 2.0 cm in front of the lens to study it. The lens has a focal length of 5.0 cm.

Calculate the distance of the image from the lens.

do = 2.0cm f = 5.0cm

1/f = 1/di + 1/do

1/5 = 1/2 + 1/di   1/5 − 1/2 = 1/Di   di = −3.3

di = 3.3cm behind the lens //

(as ans. is negative)

Correct calculation and position.

m

(b) Tom goes to a pool. He shines a red laser into the pool. He notices that even though the light ray bends, its colour does not change.

Explain why the colour of the laser remains the same.

Explained in terms of frequency.

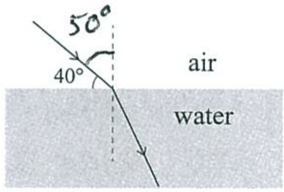
The color of an object is determined by the frequency of the light rays. The color of the laser is the same because the frequency of light does not change when it goes from one medium into another so color does not change.

a

(c) Tom shines the red laser at an angle of 40° to the surface of the water in the pool, as shown in the diagram below.

Refractive index of air = 1.00

Refractive index of water = 1.33



I = 50°

Calculate the angle of refraction.

$n_1 \sin\theta_1 = n_2 \sin\theta_2$

$1 \sin 50 = 1.33 \sin\theta_2$

$\sin^{-1}\left(\frac{\sin 50}{1.33}\right) = \theta_2$

$\theta_2 = 35.168 = 35°$ ✓ //

Correct angle of incidence and calculation.

m

(d) There is a coin at the bottom of the pool. Tom looks at the coin from above and sees an image of the coin, as shown in the diagram below.

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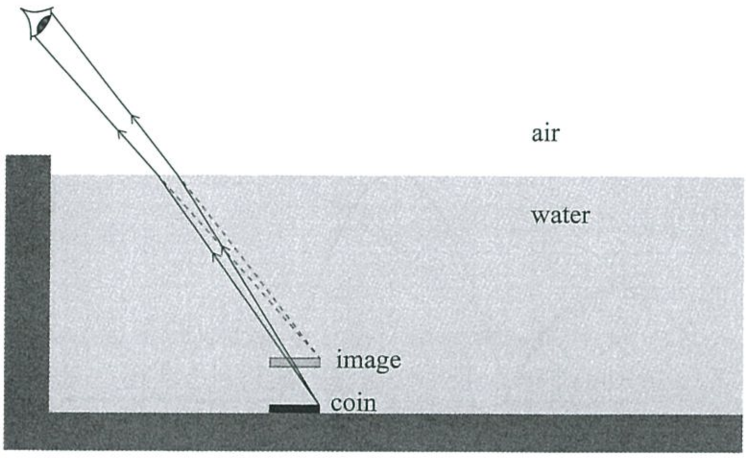


Write a comprehensive explanation for why the rays bend, and how the image of the coin at the bottom of the pool is formed when Tom looks at it from above.

The rays of light bend upon reaching the air-water boundary because ~~light~~ ~~rays~~ waves travels at different speeds in different mediums. On reaching the boundary, light rays from the more optically dense water will bend away from the normal (line 90° to the boundary) as air is less optically dense than water, and thus light travels faster in air than water. ~~Tear~~ Tracing these real rays from the coin that reach Tom's eye back, the virtual image of the coin ~~is~~ that Tom sees is shallower than where the coin is in reality.

e

Correct discussion with links made and direction of rays from object to Tom's eye.

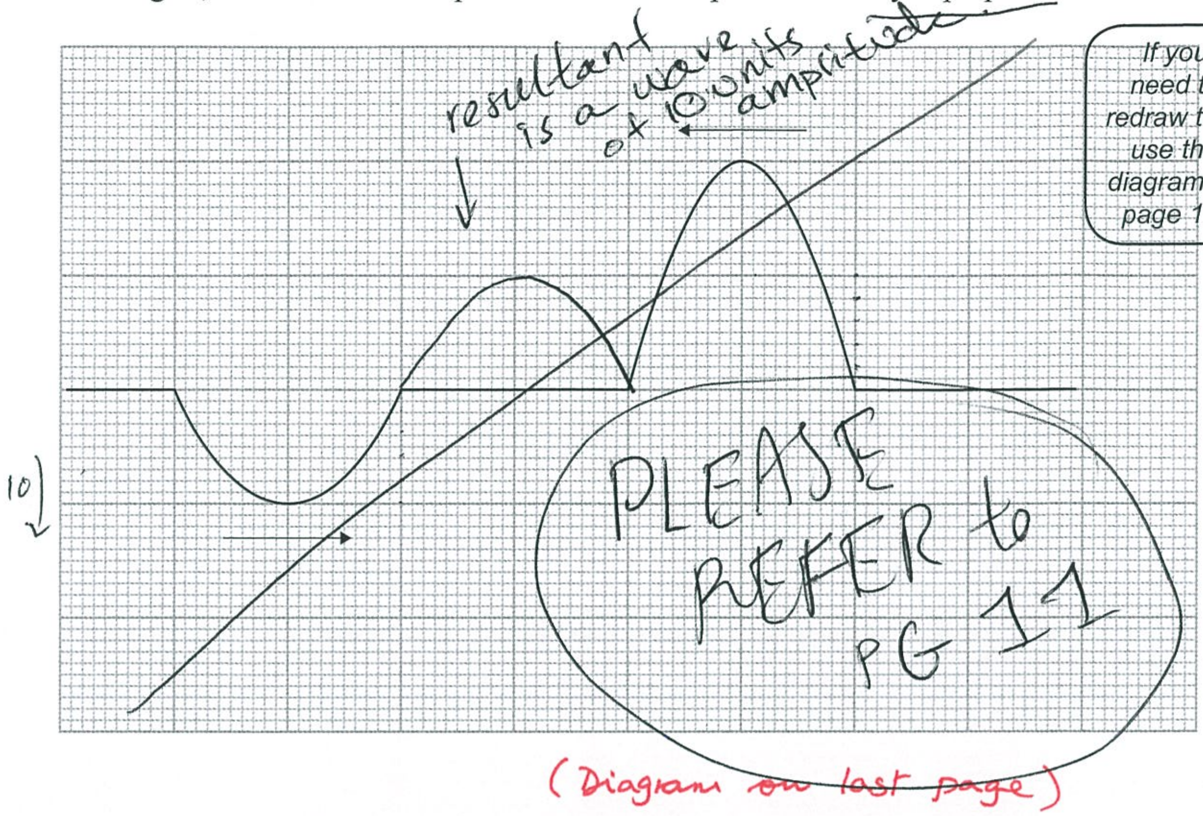
E8

QUESTION THREE: ROPES AND A MIRAGE

ASSESSOR'S USE ONLY

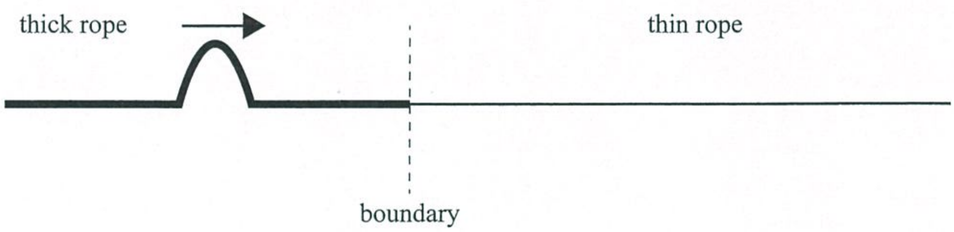
(a) Tom and his friend Ellen hold each end of a rope. Each of them sends a pulse along the rope in opposite directions. The grid below shows the motion of the pulses.

On the grid, draw the resultant pulse when the two pulses are fully superposed.

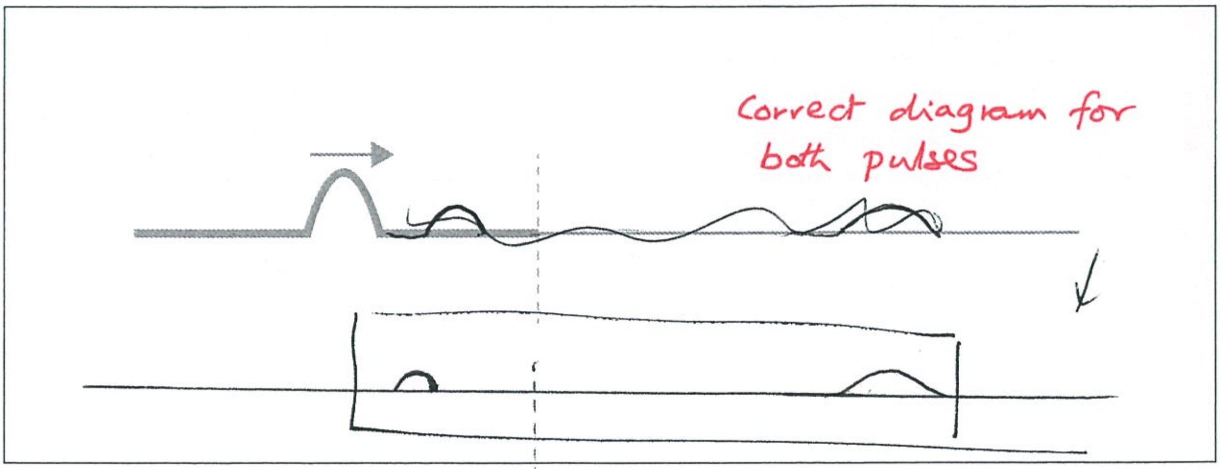


If you need to redraw this, use the diagram on page 11.

(b) Tom ties a thick rope to a thin rope, as shown in the diagram below. He then sends a pulse from the thick rope towards the thin rope. The pulse travels faster through the thin rope.



In the box below draw a diagram to show what happens to the pulse as it undergoes reflection and transmission (refraction) once it reaches the boundary between the two ropes.



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a
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(c) Explain what happens to the **amplitude** of the pulse in the thick rope when it reflects.

The amplitude of the pulse will decrease as there is a loss of energy when the ~~initial~~ pulse initially travels towards the boundary with some being reflected and some also refracting / transmitting to the lighter, thinner rope.

Correct explanation – what and why.

m

(d) Tom drives down the motorway on a hot sunny day. He notices a mirage ahead of him. A mirage is the image of the sky that has been reflected by the road. The air just above the surface of the road is hotter than the layers of air above it. Hot air is less optically dense than cold air.

Write a comprehensive explanation for why Tom sees a mirage.

cold air

hot air

Tom sees a mirage because of a phenomenon known as total internal reflection, where light rays travelling from a more optically dense medium to a less optically dense medium will be reflected if the incidence angle is greater than the critical angle required for the ray to refract at 90° to the normal. The air above the surface of the road is hotter than the layers above it, so the light rays travel from the ~~high~~ cold air where it is more optically dense, to the hot air; some may reflect off this boundary between the two, hence Tom sees the mirage.

A full explanation of how Tom may see a mirage of the sky.

e

E8

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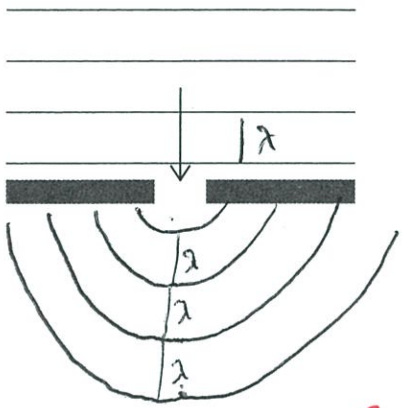
QUESTION FOUR: WAVES

(a) Tom and Ellen watch waves in the ocean. The diagram below shows the wave crests approaching a gap in a sea wall.

On the diagram, draw the wave crests after they have gone through the gap.

If you need to redraw this, use the diagram on page 11.



a

Correctly drawn diagram.

(b) Tom and Ellen stand on a beach, watching the waves. They notice that the wave fronts are closer together when they reach shallow water, as compared to the distance between wave fronts in deep water.

On one occasion, the distance between wave crests in deep water is 1.75 m. The speed of waves in deep water is 12.0 m s^{-1}. The speed of waves in shallow water is 4.5 m s^{-1}.

Calculate: λ=1.75

- the frequency of the waves
- the distance between wave crests in shallow water. λ

$v = f\lambda$

deep = 12ms^{-1} shallow = 4.5 ms^{-1}

$12 = f(1.75)$ $f = 6.9$ Hz ✓

Speed of waves in shallow water = 4.5

$4.5 = f\lambda$

$4.5 = 6.9(\lambda)$

$\lambda = 0.66$ m ✓ //

m

Both calculations correct and correct units.

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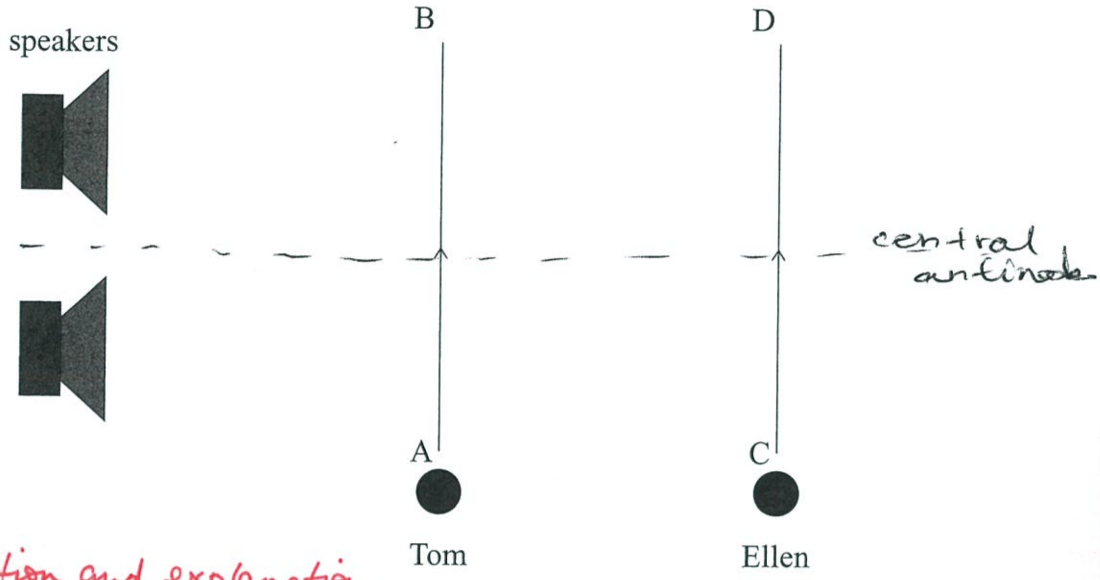
(c) Two speakers producing the same sound are placed close together.

Tom walks along line AB and Ellen walks along line CD.

- Describe the sound that Tom hears.
- Compare the sound that Tom hears with the sound that Ellen hears.

Explain your answer.



Correct description and explanation.

Tom will hear alternating loud and soft sounds as he walks along A B. This is due to superposition of the sound waves as their waves displacements add together when passing through eachother. ~~Ellen will~~ For example he will hear loud sounds along any ~~no~~ anti-nodal lines where constructive interference occurs, and soft sounds where he encounters a node (an area of no energy as the waves destructively interfere). ✓

Both Tom and Allen will hear sounds that appear loud and ~~soft~~ as they walk along their lines, another similarity being they will hear the loudest sound when they are right in the middle of the two speakers (area where central antinode line is). However Tom is much closer to the speakers than Ellen, so the ~~waves~~ sound appears generally quieter by the time it reaches Ellen and more soft-quiet areas as there waves have spread out greatly and there are more areas of destructive interference compared to Tom - who is closer to the speaker where the sound is generally louder//

m

Question Four continues on the following page.

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(d) Tom shines a red laser through the two slits and gets the following pattern on a screen.

Write a comprehensive explanation for why there are alternate bright and dark bands on the screen.

In your answer include concepts about path difference and interference.

The alternate bright + dark bands demonstrate superposition, and the fact that when light passes through the two slits there will be areas of light + dark because there will be points of constructive + destructive interference. interference is when two ~~tw~~ waves (in this case light) will superimpose, their amplitudes adding as they pass through eachother to produce a resultant wave. The ~~light~~ bright bands demonstrate constructive interference, where the waves which are superimposing are an even number of 1/2 wavelengths apart, so their displacements add together with maximum energy at this point. The dark bands demonstrate destructive interference, where the light ~~rays~~ waves ~~at~~ superimposing are an odd number of 1/2 wavelengths apart thus the displacements cancel eachother out and there is no energy. The ~~areas~~ lines of destructive interference are called nodal, and constructive -antinodal.//

e

A complete explanation of the phenomenon that includes the explanation relating to path difference as well as interference.

E8

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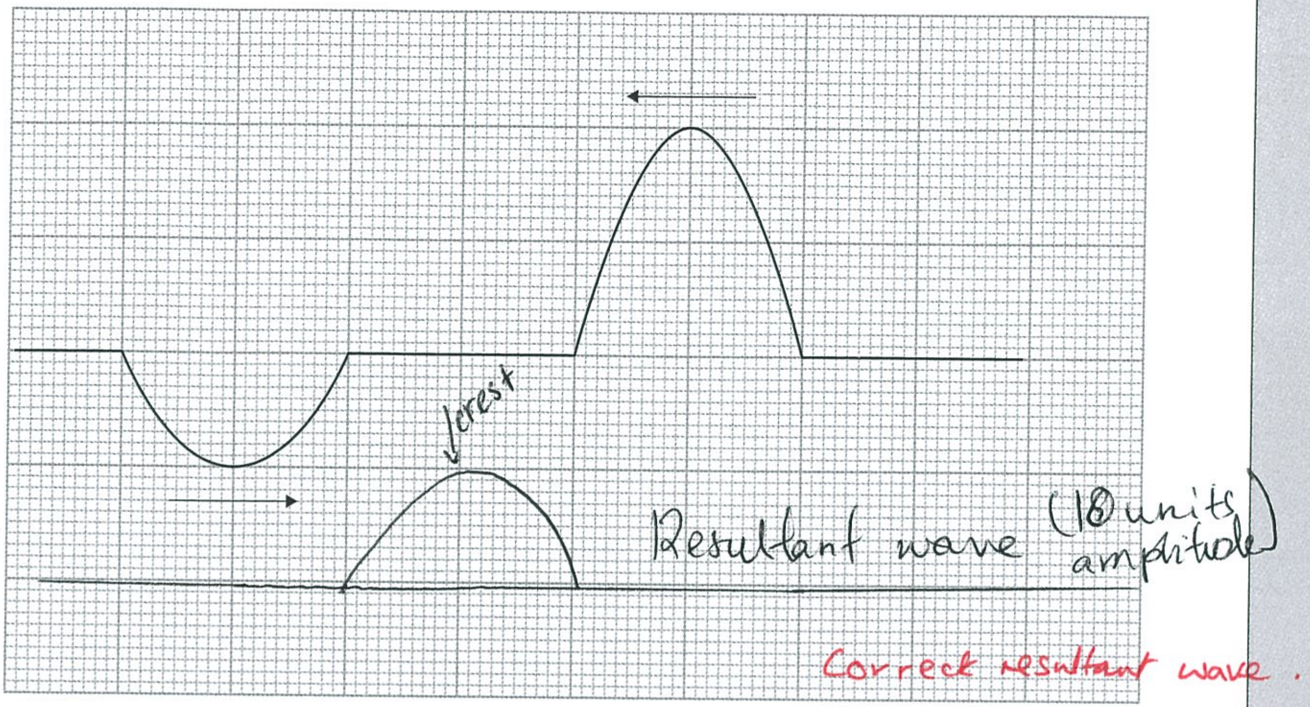
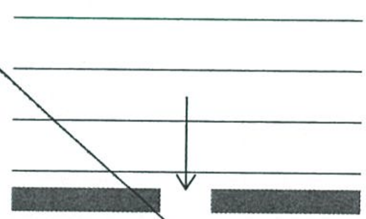
SPARE DIAGRAMS

If you need to redraw the pulse from Question Three (a), draw it on the diagram below. Make sure it is clear which diagram you want marked.



Seen

If you need to redraw your completion of the diagram from Question Four (a), draw it on the diagram below. Make sure it is clear which diagram you want marked.



Extra paper if required.
Write the question number(s) if applicable.

QUESTION NUMBER

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