SPECIMEN

Advanced GCE

Applied Science

Working Waves

Specimen Paper

G635

Time: 1 hour 30 minutes

Candidates answer on the question paper.

Additional materials:
None

Candidate Forename		Candidate Surname	

Centre Number						Candidate Number				

INSTRUCTIONS TO CANDIDATES

- Write your name in capital letters, your Centre Number and Candidate Number in the boxes above.
- Use black ink. Pencil may be used for graphs and diagrams only.
- Read each question carefully and make sure you know what you have to do before starting your answer.
- Answer **all** the questions.
- Do not write in the bar codes.
- Write your answer to each question in the space provided.

INFORMATION FOR CANDIDATES

- The number of marks for each question is given in brackets **[ ]** at the end of each question or part question.
- The total number if marks for this paper is **90**.
- You are advised to show all the steps in any calculations.
-  Where you see this icon you will be awarded marks for the quality of written communication in your answer.
- You may use an electronic calculator.
- This document consists of **12** pages. Any blank pages are indicated.

  [100/4440/1] [100/4445/0]

Answer **all** the questions.

1

(a) Waves are vital to communication. Communications systems use sound, light, radio waves and microwaves.

(i) State which of the waves mentioned above is **not** a type of electromagnetic radiation.

..... **[1]**

(ii) Name **one** of the waves mentioned above that is a transverse wave.

..... **[1]**

(iii) Compare the velocity, frequency, and wavelength of light with radio waves when they travel in a vacuum.

velocity.....

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frequency.....

.....

wavelength.....

..... **[3]**

(iv) **I** Compare the penetration into matter by light and radio waves.

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II Give an example of a material which can be penetrated by one type of wave but not the other.

..... is penetrated by **light / radio waves * [2]**

*** delete one**

(b) Musical sound is used not just for communication but also for pleasure. Sound waves in air can be created by standing waves in strings.

A music teacher uses equipment in the Physics laboratory to show how stringed instruments vibrate. In the demonstration, standing waves are set up in a wire by passing a small, oscillating electric current along it.

The current comes from a signal generator which can produce currents at any chosen frequency. A magnet is placed with its poles either side of the wire to make the wire oscillate at the frequency of the oscillator.

The teacher shows how nodes and antinodes are formed in the wire at certain frequencies.

In the demonstration, the results shown in Table 1.1 were obtained.

Table 1.1

Oscillator frequency /Hz	Separation of adjacent nodes /m
100	**2.00**
200	**1.00**
300	**0.67**
400	**0.50**

The length of the wire was constant at 2.00 m and the tension was not changed during this experiment.

(i) Draw diagrams to illustrate the standing wave in the wire for the first and last result. On your diagrams mark the nodes ‘N’ and the antinodes ‘A’.

1. Diagram of the standing wave when frequency = 100 Hz

[2]

2. Diagram of the standing wave when frequency = 400 Hz

[2]

(ii) Explain why it is possible for a wire to resonate at different frequencies when its length and tension are unchanged.

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..... **[4]**

(iii) State the equation linking the velocity of a wave to its wavelength and frequency. Use the data given in Table 1.1 to calculate the wavelength and velocity of the wave for the first and last row of the table. Include the correct units in your answer.

wave equation……

first row:

wavelength……..……units……

velocity……..……units……

last row:

wavelength……..…units……

velocity……...……units……

[6]

(c) The note, middle C, of a piano is quite different from middle C of a saxophone. Describe the characteristics of waveforms of these or other instruments which differ when different instruments play the **same** note. You are not required to identify which instruments have which characteristics.

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..... **[3]**

[Total 24]

2

(a) In a steel mill, the temperature of a sheet of steel in a **very** hot furnace can be determined from its colour.

(i) Describe the spectrum of radiation emitted by steel immediately it comes out of a **very** hot furnace.

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..... **[4]**

(ii) Describe how the radiation emitted by the steel changes as it cools.

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..... **[6]**

(b) Thermal imaging cameras are used in industry to monitor objects that would otherwise not be visible. For example, at Snodkins Plastics, the level of liquids in storage tanks is monitored this way.

A storage tank is shown in Fig. 2.1. The liquid inside the tank cannot be seen. Fig. 2.2 shows an image of the same tank taken using a thermal imaging camera.

Fig. 2.1

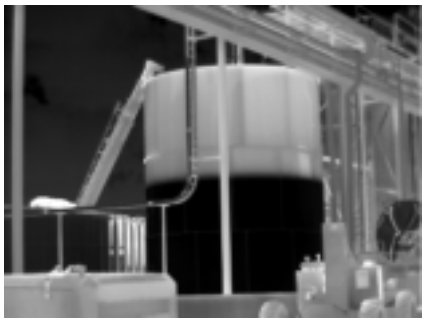

Fig. 2.2

(i) Using Fig. 2.2, explain how the liquid level in the tank can be seen using thermal imaging.

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..... **[2]**

(ii) A thermal imaging camera is used to examine a machine.

A picture is taken when the machine has not been run for a long time. In this picture, the components of the machine all appear the same colour. A second picture is taken after the machine has been operating continuously for an hour. In this image, a pulley wheel on the machine can be clearly identified, but the edges appear blurred.

Explain these observations and suggest how the second image might be used by an engineer to identify a fault that is causing overheating in the driving engine.

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..... **[5]**

[Total 17]

3

(a) In an endoscope such as that shown in Fig. 3.1, optical fibres are commonly bundled together into cables. The bundles of fibre used to view the image in an endoscope are coherent.

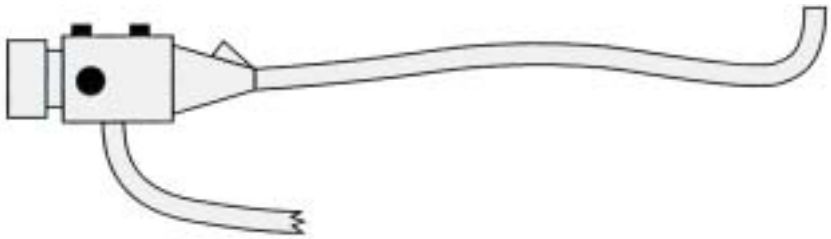

Fig.3.1

Discuss whether coherent bundles are appropriate for all applications of optical fibres.

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..... **[3]**

(b) Another important application of fibre optics is for communications. Graded-index and step-index optical fibres have both been used for this purpose. Step-index fibres have a cladding of glass outside the glass core as shown in Fig. 3.2.

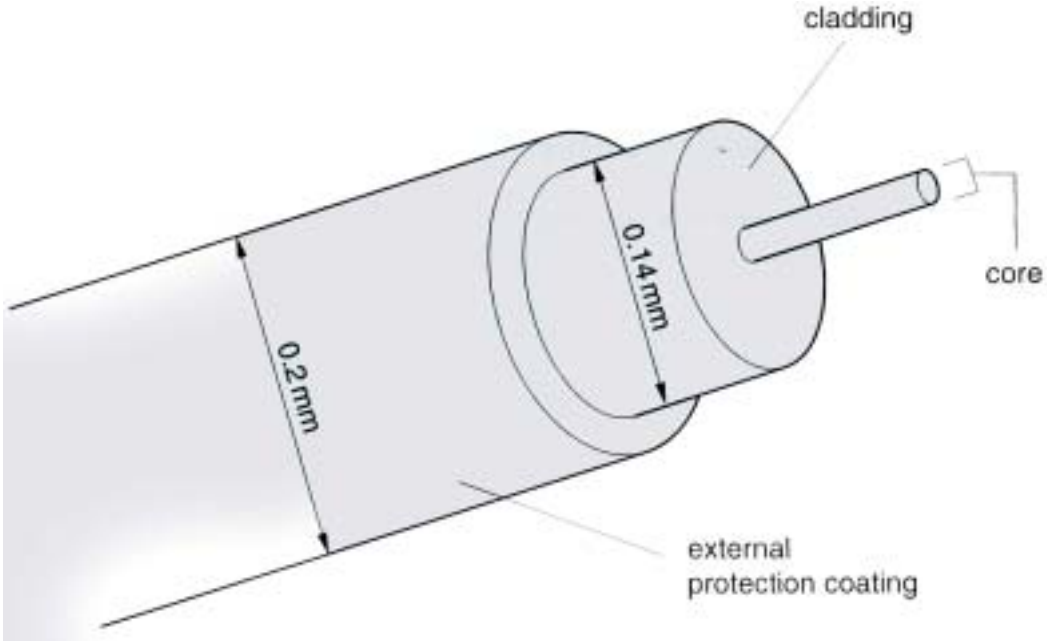

Fig 3.2

(i) State how the refractive index of the cladding compares to that of the core?

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..... **[1]**

(ii) Step-index optical fibres are not often used for communications because they degrade the signal.

1. Explain why this degradation takes place.

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..... **[2]**

2. Draw a diagram to show the shape of a square wave signal after it has been degraded in this way.

[2]

3. Describe how graded-index optical fibres overcome this problem.

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..... **[3]**

(c) Fibre-optic cables have now replaced metallic conductors for long-distance transmission. State **three** advantages of fibre-optic transmission compared to transmission by electric currents in metallic conductors.

1.....

2.....

3..... **[3]**

[Total 14 marks]

4

(a) A radio presenter states that her programme is broadcast "… on AM, on FM, on digital and online".

(i) Sketch a section of an AM (amplitude-modulated) signal on the axes given in Fig. 4.1.

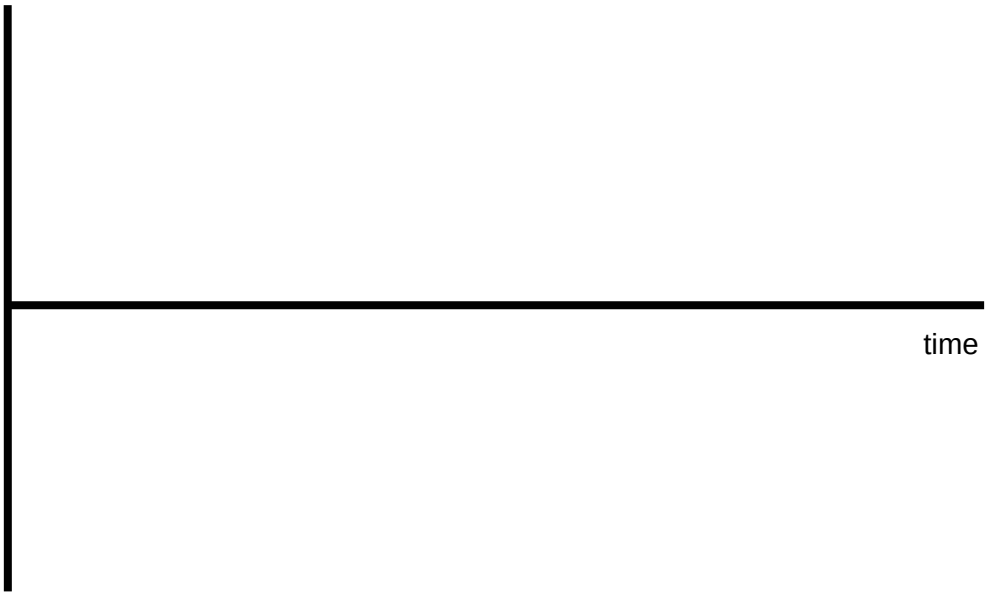

Fig. 4.1

[3]

(ii) Sketch a section of an FM (frequency modulated) signal on the axes given in Fig. 4.2.

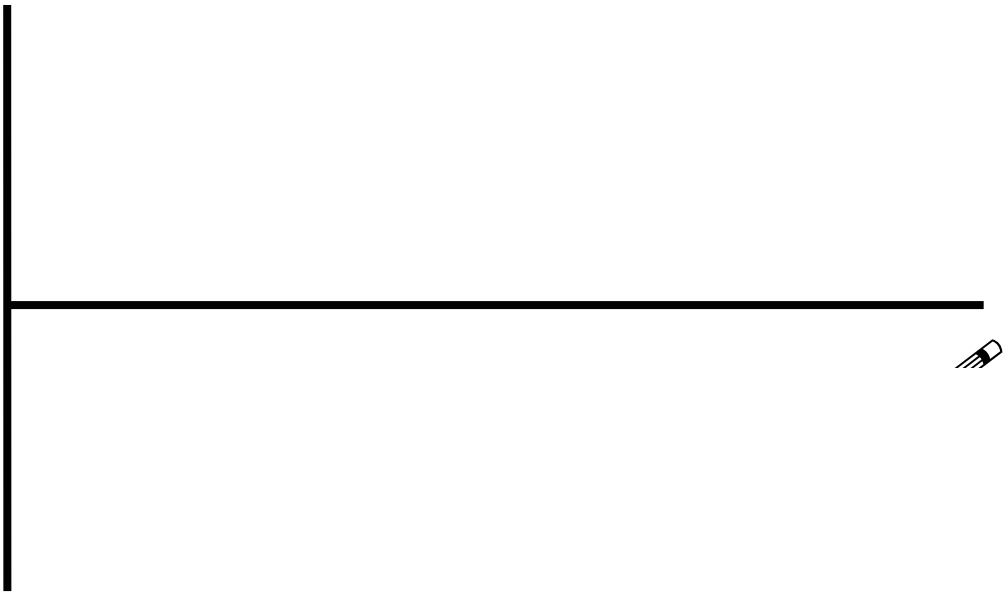

Fig. 4.2

[3]

(iii) Explain why the quality of FM signals is better than that of AM signals.

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..... **[2]**

(iv) Online radio transmission enables people all over the world to receive the same BBC broadcasts that we enjoy in the UK. Many people receive online radio transmission using broadband telephone systems. State and explain the difference between broadband and normal telephone signals.

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..... **[4]**

(b) Until a few years ago, mobile communications were only available to a few people such as the emergency services.

Describe and explain the contributions of multiple access and cellular technologies to the widespread availability of mobile phones.

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.....**[6]**

[Total 18]

5 Following a road traffic accident, a motorcyclist is taken to the radiography department of her local hospital. The radiography department uses X- and γ-rays for imaging.

(a) The motorcyclist's leg is X-rayed. Explain why the motorcyclist's bones show up on the X-ray image more clearly than soft tissue.

.....

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..... **[3]**

(b) X-rays have harmful effects.

(i) The motorcyclist is pregnant, but the doctor still recommends that an X-ray is needed.

Suggest what special precaution a radiographer might take with this patient.

.....

..... **[2]**

(ii) Suggest **two** actions the radiographer might take to protect himself.

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..... **[2]**

(c) How do X-rays damage cells?

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..... **[5]**

(d) The radiographer also operates a CAT scanner. CAT scanners can produce much more detailed information than conventional X-ray machines. Explain why.

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..... **[5]**

[Total 17]

Paper Total [90]

OXFORD CAMBRIDGE AND RSA EXAMINATIONS

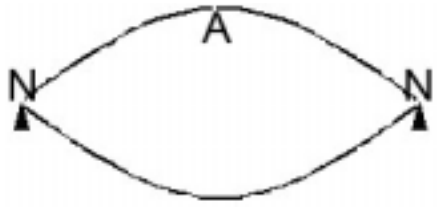
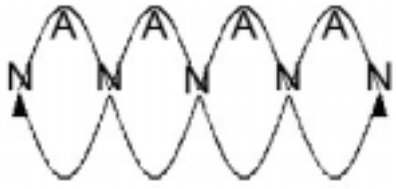
Advanced GCE

APPLIED SCIENCE G635

Working Waves

Specimen Mark Scheme

The maximum mark for this paper is [90].

Question Number	Answer	Max Mark
1(a)(i)	**Waves are vital to communication. Communications systems use sound, light, radio waves and microwaves.** **State which of the waves mentioned above is not a type of electromagnetic radiation.** sound	**[1]**
1(a)(ii)	**Name one of the waves mentioned above that is a transverse wave.** (visible) light/radio/microwaves	**[1]**
1(a)(iii)	**Compare the velocity, frequency, and wavelength of light with radio waves when they travel in a vacuum.** velocity all same; light greater frequency/radio smaller frequency; light shorter wavelength/radio longer wavelength;	**[3]**
1(a)(iv)	**I. Compare the penetration into matter by light and radio waves.** radio waves more penetrating; accept valid exception e.g. light can go through metal grid / mesh	**[1]**
	II. Give an example of a material which can be penetrated by one type of wave but not the other. e.g. brick is penetrated by <u>light / radio waves</u>	**[1]**
1(b)(i)	**Draw diagrams to illustrate the standing wave in the wire for the first and last result. On your diagrams mark the nodes 'N' and the antinodes 'A'** 1. diagram showing maximum displacement in centre of string labelled A; zero displacement at ends only labelled N; e.g.  2. diagram showing Four antinodes correctly spaced labelled A; Five nodes correctly spaced labelled N; e.g.  	**[1]** **[1]** **[1]** **[1]**

Question Number	Answer	Max Mark
1(b)(ii)	**Explain why it is possible for a wire to resonate at different frequencies when its length and tension are unchanged.** any four of the following: fundamental; harmonics/overtones; length of wire must be whole number of half wavelengths; more than one wavelength meets this requirement; corresponding frequencies/more than one frequency meets this requirement; $l=n\lambda/2$;	**[4]**

1(b)(iii)	**State the wave equation and use the data given in Table 1.1 to calculate the wavelength and velocity of the wave for the first and last row of the table. Include the correct units in your answer.**
	$v = f\lambda$
	row 1: $\lambda = 2 \times 2.00 = 4.00$ m;
	$v = f\lambda = 100 \times 4.00 = 400$ m s^{-1};
	row 4 $\lambda = 2 \times 0.50 = 1.00$ m;
	$v = f\lambda = 400 \times 1.00 = 400$ m s^{-1};
	one mark for correct units
		[1]
		[1]
		[1]
		[1]
		[1]
		[1]

1(c)	**The note, middle C, of a piano is quite different from middle C of a saxophone. Describe the characteristics of waveforms of these or other instruments which differ when different instruments play the same note. You are not required to identify which instruments have which characteristics.** Any three valid points e.g. Some have overtones; proportions of overtones differ; some overtones may not be present; for some instruments, overtones are all multiples of fundamental frequency; for some instruments, overtones are only odd multiples of fundamental frequency; loudness /intensity/ amplitude may differ; different duration of note; different way in which amplitude grows and dies away/envelope;	**[3]**

Question Number	Answer	Max Mark
2(a)(i)	**In a steel mill, the temperature of a sheet of steel in a very hot furnace can be determined from its colour.** **Describe the spectrum of radiation emitted by steel immediately it comes out of a very hot furnace.** white; contains all colours/frequencies/wavelengths of the visible spectrum/light; plus infrared radiation; reference to variation in intensity at different frequencies; [allow credit for alternative correct points] [accept graphs] [allow 1 mark only for yellow]	**[1]** **[1]** **[1]** **[1]**
2(a)(ii)	**Describe how the radiation emitted by the steel changes as it cools.** **Banded mark scheme:** **[5-6 marks]** Candidate demonstrates a high level of understanding by describing, **in the correct sequence**, the visual appearance of the steel as it cools in terms of the colours i.e. red/orange/yellow/no visible radiation emitted and links these to the intensities emitted at different frequencies. In particular they will describe how the intensity of radiation emitted decreases across all frequencies/wavelengths, but particularly at higher frequencies/shorter wavelengths. In addition they will demonstrate a clear understanding that infra-red radiation is emitted <u>at all temperatures</u> and in particular when no visible light is emitted. There are few, if any, errors in spelling, punctuation and grammar. **[3-4 marks]** Candidate demonstrates an understanding by describing, **in the correct sequence,** the visual appearance of the steel as it cools in terms of the colours i.e. red/orange/yellow/no visible radiation emitted and links these to the intensities emitted at different frequencies. In particular they will describe how the intensity of radiation emitted decreases across all frequencies/wavelengths, but particularly at higher frequencies/shorter wavelengths. There may be occasional errors in spelling, punctuation and grammar. **[1-2 marks]** Candidate describes the visual appearance of the steel as it cools in terms of the colours i.e. red/orange/yellow/no visible radiation emitted. To achieve both these marks candidates will include correct sequencing of these changes. Errors of grammar punctuation and spelling may be intrusive.	**[6]**

[0 mark]: no response / response not worthy of credit.

2(b)(i) **Using Fig 3.2, explain how the liquid level in the tank can be seen using thermal imaging.**

two appropriate points e.g.

full and empty parts of the tank at different temperatures/liquid at a different temperature to surroundings;

different temperatures emit different intensity/

frequency/wavelength {of Infrared/electromagnetic radiation);

shows as different colours/shades of grey on photograph;

[not enough just to say giving off IR/camera detects IR must show difference] **[2]**

2(b)(ii) **A thermal imaging camera is used to examine a machine. A picture is taken when the machine has not been run for a long time. In this picture, the components of the machine all appear the same colour. A second picture is taken when the machine is stopped after operating for an hour. In this image, a pulley wheel on the machine can be clearly identified, but the edges appear blurred.**

Explain these observations and suggest how the second image might be used by an engineer to identify a fault that is causing overheating in the driving engine.

Band mark range:

[5 marks] Candidate demonstrates a high level of understanding of thermal imaging by explaining that:

- in the first picture, all components are at the same temperature, so emit the same frequency /wavelength and/or the same intensity of infra-red radiation.
- in the second picture, friction has made the pulley wheel warmer so that it emits a different frequency/wavelength/greater intensity of infra-red radiation.
- The edges of the pulley wheel in the second image are blurred because there is a gradual change in temperature/temperature gradient across the boundary between components.
- Overloading of the motor is caused by excessive friction which makes the faulty component hotter.

There are few, if any, errors in spelling, punctuation and grammar.

[3-4 marks] Candidate demonstrates understanding of thermal imaging by explaining that:

- in the first picture, all components are at the same temperature, so emit the same frequency /wavelength and/or the same intensity of infra-red radiation.
- in the second picture, friction has made the pulley wheel warmer and made the faulty component hotter so that they emit different frequencies/wavelengths/greater intensities of infra-red radiation.

There may be occasional errors in spelling, punctuation and grammar.

. **[5]**

[1-2 marks] Candidate shows basic knowledge of thermal imaging by showing understanding that

- in the first picture, all components are at the same temperature.
- in the second image, the pulley wheel is warmer is and the faulty component would be hotter.

Errors of grammar punctuation and spelling may be intrusive.

[0 mark]: no response / response not worthy of credit.

Question Number	Answer	Max Mark
3(a)	**In an endoscope such as that shown in Fig 4.1, optical fibres are commonly bundled together into cables. The bundles of fibre used to view the image in an endoscope are coherent. Discuss whether coherent bundles are appropriate for all applications of optical fibres.** **Band mark range:** **[3 marks]** Candidate demonstrates a high level of understanding of the difference between coherent and incoherent bundles, and of what they can transmit. They link this to cost effectiveness. Candidate will incorporate five valid points expressed clearly and logically clearly linking the structure of the fibres to their practical applications. There are few, if any, errors in spelling, punctuation and grammar. **[2 marks]** Candidate demonstrates an understanding of the difference between coherent and incoherent bundles, and of what they can transmit. They link this to cost effectiveness. Candidate will incorporate at least three valid points expressed clearly and logically. There may be occasional errors in spelling, punctuation and grammar. **[1 mark]** Candidate shows basic knowledge of the difference between coherent and incoherent bundles and their cost. Candidates will incorporate at least two valid points. E.g. coherent bundles have parallel fibres / arrangement of fibres is the same at both ends, coherent bundles are more expensive. Knowledge is not linked to practical application. Errors of grammar punctuation and spelling may be intrusive. **[0 mark]:** no response / response not worthy of credit. **Expected knowledge and understanding could include the following valid points:** • coherent bundles have fibres parallel/arrangement of fibres is same at both ends/throughout; • incoherent bundles have fibres arranged at random/arrangement of fibres is not the same at both ends/throughout/not parallel; • If transmitting images/data coherent fibres are needed so that the image/data is not mixed up/ distorted; • illumination/(single) TV/computer link order does not matter; • Incoherent cheaper/easier to make; • AVP;	**[3]**
3(b)(i)	**State how the refractive index of the cladding compares to that of the core?** less	**[1]**

Question Number	Answer	Max Mark
3(b)(ii)	**Step-index optical fibres are not often used for communications because they degrade the signal.** **1. Explain why this degradation takes place.** **2. Draw a diagram to show the shape of a square wave signal after it has been degraded in this way.** **3. Describe how graded-index optical fibres overcome this problem.** 1 Any two from: different path lengths; different times to travel down fibre; depending on angle light enters fibre; depending on number of internal reflections; 2 Square wave with: vertical line sloping to right when increasing; vertical line sloping to right when decreasing; allow with shaped or curved “corners” 3 Any three from: refractive index changes gradually; path lengths similar; refractive index decrease from the centre; ray with longer path/path further from centre travels faster;	**[2]** **[2]** **[3]**
3(c)	**Fibre optic cables have now replaced metallic conductors for long-distance transmission. State three advantages of fibre-optic transmission compared to transmission by electric currents in metallic conductors.** any three from: very large information capacity; low material costs; lasts longer; small cable size; negligible crosstalk; high immunity to interference; complete electrical isolation; large repeater spacing/longer distances/less attenuation/degradation in same distance; more secure;	**[3]**

Question Number	Answer	Max Mark
4(a)(i)	**A radio presenter states that her programme is broadcast "…. on AM, on FM, on digital and online".** **Sketch a section of an AM (amplitude-modulated) signal on the axes given in Fig 4.1.**	
	Suitable number of cycles of (sine) wave shown;	**[1]**
	amplitude of wave varies;	**[1]**
	at least one modulation cycle shown;	**[1]**
4(a)(ii)	**Sketch a section of an FM (frequency modulated) signal on the axes given in Fig 4.2.**	
	Suitable number of cycles of (sine) wave shown;	**[1]**
	frequency of wave varies;	**[1]**
	at least one modulation cycle shown;	**[1]**
4(a)(iii)	**Explain why the quality of FM signals is better than that of AM signals.**	
	interference/attenuation of the signal affects amplitude;	**[1]**
	frequency unaffected by interference;	**[1]**
4(a)(iv)	**Online radio transmission enables people all over the world to receive the same BBC broadcasts that we enjoy in the UK. Many people receive online radio transmission using broadband telephone systems. State and explain the difference between broadband and normal telephone signals.**	
	any four appropriate points e.g. faster transfer of information/data; telephone <u>bandwidth</u> much less than broadband; telephone bandwidth <4 kHz [accept any value 1 -1 0 kHz]; broadband bandwidth several M Hz [accept any value 1 – 10 MHz]; sound quality much better; more information carried by greater bandwidth; so higher/greater range of audio frequencies transmitted;	**[4]**

Question Number	Answer	Max Mark
4(b) 	**Until a few years ago, mobile communications were only available to a few people such as the emergency services.** **Describe and explain the contributions of multiple access and cellular technologies to the widespread availability of mobile phones.** **Band mark range:** **[5-6 marks]** Candidate demonstrates a high level of knowledge and understanding of cellular and multiple access technologies incorporating at least eight valid points. In-depth explanations of their contribution to the widespread distribution of mobile phones are given appropriately, and include discussion of social implications. E.g. • availability where no landlines exist (e.g. developing countries) • safety of people in isolated places / calling emergency services from mountains/boats Ideas are well argued and expressed clearly and logically. There are few, if any, errors in spelling, punctuation and grammar. **[3-4 marks]** Candidate demonstrates detailed knowledge of cellular and multiple access technologies incorporating at least five valid points. Explanations of their contribution to the widespread distribution of mobile phones are mainly correct. Ideas are expressed clearly and logically. There may be occasional errors in spelling, punctuation and grammar. **[1-2 marks]** Candidate shows basic knowledge of cellular technology and multiple access technology incorporating at least two valid points. Little or no explanation of their contribution to the widespread distribution of mobile phones is given. Errors of grammar punctuation and spelling may be intrusive. **[0 mark]:** no response / response not worthy of credit. **Expected knowledge and understanding could include the following valid points:** • More calls can be made using a limited range of frequencies; • multiple access technology means sharing of frequencies between many users; • by giving each a segment of time; • or coding the signal ; • cellular technologies means division into of geographical areas called cells; • normally hexagonal; • cell diameter any value 0.5 – 20 miles/1-32 km or equivalent;	**[6]**

	• base station corresponding to each cell; • location of base station [accept either near centre of cell or a point where three cells meet; • frequencies can be reused in non-adjacent cells;	
5(a)	**Following a road traffic accident, a motorcyclist is taken to the radiography department of her local hospital. The radiography department uses X- and γ-rays for imaging.** **The motorcyclist's leg is X-rayed. Explain why the motorcyclist's bones show up on the X-ray image more clearly than soft tissue.** bone absorbs X-rays (more than fat/other tissues); bone higher atomic No./density so bones cast a shadow or wtte;	**[1]** **[1]** **[1]**
5(b)(i)	**X-rays have harmful effects.** **The motorcyclist is pregnant, but the doctor still recommends that an X-ray is needed.** **Suggest what special precaution a radiographer might take with this patient** any two sensible suggestions. e.g. lead apron/shield; appropriate location; take fewer images;	**[2]**
5(b)(ii)	**Suggest two actions the radiographer might take to protect himself.** any two sensible suggestions. e.g. leave room/stand behind screen; wear (film) badge/dosemeter; wear lead apron;	**[2]**

Question Number	Answer	Max Mark
5(c)	**How do X-rays damage cells?** ionises; and any four further points e.g. ions interact (with water molecules resulting in a number of new products); reaction products interact with molecules of the cell; causing early death of a cell; prevention or delay of cell division; permanent modification which is passed on to daughter cells; NOT diseases, must focus on cells	**[1]** **[4]**
5(d)	**The radiographer also operates a CAT scanner. CAT scanners can produce much more detailed information than conventional X-ray machines. Explain why.** any five appropriate points e.g. CAT scanner uses X-Rays; conventional X-ray pictures show information from all depths in the body superimposed on each other; CAT scanner images one slice of the body at a time; sharp image is obtained by changing the direction of the X-Rays and using multiple positions of the detector; The information from these scans is processed by a computer to obtain the final image; rotate; 3D; provides more information; images soft tissue;	**[5]**
	Paper Total	**[90]**

Assessment Objectives Grid (includes QWC)

Question	AO1	AO2	AO3	Total
1(a)(i)	1	-	-	**1**
1(a)(ii)	1	-	-	**1**
1(a)(iii)	3	-	-	**3**
1(a)(iv)	2	-	-	**2**
1(b)(i)1	-	2	-	**2**
1(b)(i)2	-	2	-	**2**
1(b)(ii)	-	4	-	**4**
1(b)(iii)	1	5	-	**6**
1(c)	-	3	-	**3**
2(a)(i)	2	2	-	**4**
2(a)(ii)	-	6	-	**6**
2(b)(i)	2	-	-	**2**
2(b)(ii)	-	3	-	**3**
2(c)	2	-	-	**2**
3(a)(i)	1	-	-	**1**
3(a)(ii)	-	1	-	**1**
3(b)	1	-	-	**1**
3(c)(i)	1	-	-	**1**
3(c)(ii)1	2	-	-	**2**
3(c)(ii)2	2	-	-	**2**
3(c)(ii)3	-	3	-	**3**
3(d)	3	-	-	**3**
4(a)(i)	3	-	-	**3**
4(a)(ii)	3	-	-	**3**
4(a)(iii)	2	-	-	**2**
4(a)(iv)	-	4	-	**4**
4(b)	2	4	-	**4**
5(a)	3	-	-	**3**
5(b)(i)	1	1	-	**2**
5(b)(ii)	1	1	-	**2**
5(c)	5	-	-	**5**
5(d)	1	4	-	**5**
Totals	**45**	**45**	**0**	**90**