CHEMOLOGY EDUCATION SERVICES

Name:________________________

2010 PHYSICS UNIT 4
TRIAL EXAM

Time allowed: 1 hour 30 minutes

QUESTION AND ANSWER BOOKLET

Structure of booklet

Area of study	*Number of questions*	*Marks available*	*Suggested time (minutes)*
1. Electric Power	18	40	40
2. Interactions of Light and Matter	13	30	30
3.1 Synchrotron and its applications	10	20	20
3.2 Photonics	10	20	20
3.3 Sound	10	20	20

Directions to students
This booklet is 23 pages long.
You should answer all questions in Areas of Study 1 and 2.
You should answer all questions in your selected Detailed Study in Area of Study 3.
(Note: You should choose only **ONE** Detailed Study and answer **only** questions from that Study)
You may use an A4 page of notes annotated on both sides.
There is a total of 90 marks available.
It is suggested that you spend about 1 minute per mark.

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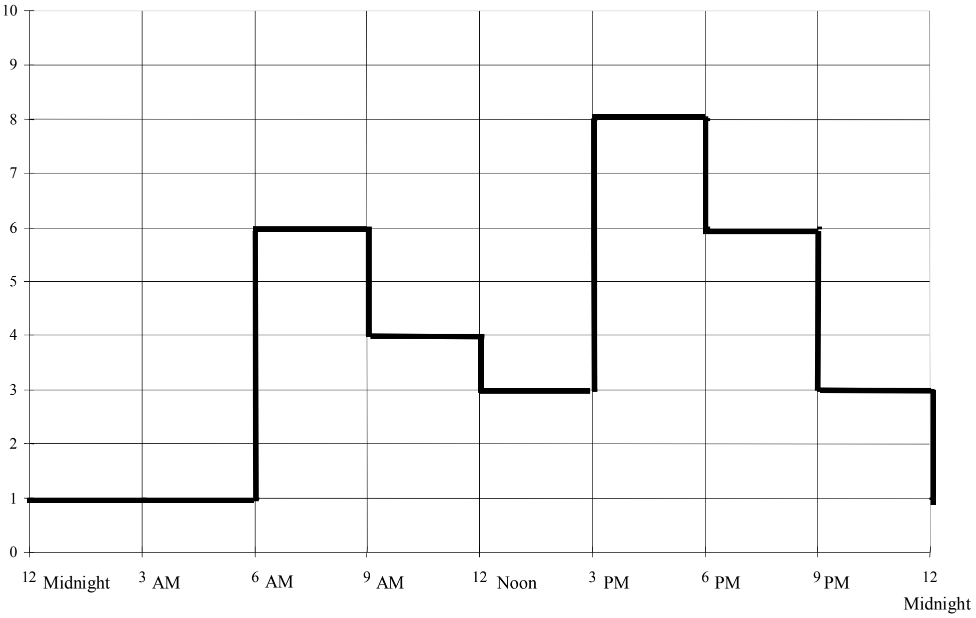
AREA 1 – ELECTRIC POWER

Specific Instructions for Area 1

Area 1 consists of **18 questions**.
A total of **40 marks** is available for Area 1.

Marcellina has just received her electricity bill and notices a new feature on the bill, a graph which provides information about her average daily power usage over the billing period. This graph is shown in Figure 1. The mains supply to the house is 240V RMS.

Power usage (kW)



Time

Figure 1

Question 1

Explain why the graph would have the shape shown in Figure 1.

____

____

____

____

2 marks

Area 1 continued

Question 2

How much energy was used in the 24 hour period?

J

2 marks

Question 3

What was the peak voltage supplied to the house at 8am?

V

2 marks

Question 4

What is the definition of an RMS voltage value?

2 marks

Marcellina also learns that voltages are "stepped up" via transformers at the substation before being delivered to her house.

Question 5

Explain why voltages are "stepped up" to higher values for transmission, rather than just being transmitted at the standard 240V RMS.

3 marks

Area 1 - continued

Marcellina's friend Basilio pops over for lunch, bringing with him two bar magnets. He puts them down on the table as shown in Figure 1 below.

Figure 2

Question 6

On the copy of Figure 2 below, draw on the magnetic field lines.

2 marks

Question 7

Why is the configuration of magnets above commonly used in Physics experiments on electricity and magnetism?

____

____

____

____

2 marks

Marcellina and Basilio have a lovely lunch and then head out to the shed to tinker with some electrical equipment. They build a basic generator by attaching a magnet to the end of a long lever and allowing it to oscillate up and down through a coil of area 0.7m^2, as shown in Figure 3. The coil consists of 40 turns.

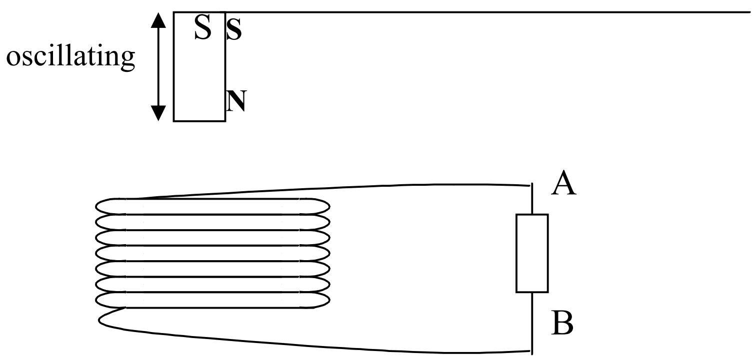


Figure 3

Area 1 - continued

The sketch graph in Figure 4 shows the variation in magnetic flux through the coil over time, as the magnet moves in and out of the coil.

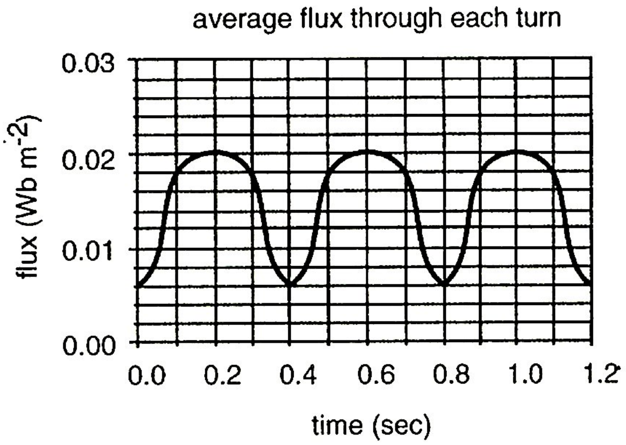


Figure 4

Question 8

Calculate the magnitude of the average emf generated between t=0.4 and t=0.6 seconds.

V

2 marks

Question 9

Draw a sketch graph of the variation of emf over the coil as a function of time, for t=0.1 to t=0.3 seconds.

3 marks

Area 1 – continued

The generator is now connected to a load of resistance 6.8Ω.

Question 10

Assuming that the resistance of the coil is negligible, calculate the average current that the generator will supply.

A

2 marks

Basilio now places a rectangular coil, which has 7 turns and side lengths 21cm and 9cm between the poles of the magnets. The magnetic field in that region is of uniform strength 0.4T. He then passes a current of 1.3A through the coil as shown in Figure 5 below.

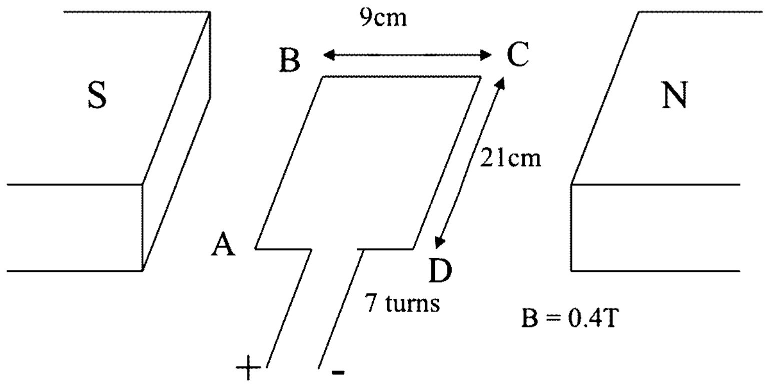


Figure 5

Question 11

What is the magnitude and direction of the force on side CD of the coil?

Size: N
Direction:

2 marks

Question 12

Which of the following would **NOT** make the coil turn faster:

A Decreasing the current
B Using magnets that produce a greater magnetic field strength
C Using a greater number of turns in the coil
D Using coils with larger side lengths

2 marks

Area 1 - continued

Marcellina and Basilio start discussing DC generators and Marcellina says that slip rings are used in a DC generator. Basilio disagrees, and says that DC generators cannot use slip rings because they must produce DC, and that a commutator must be used.

Question 13

Who is correct? Justify your answer.

3 marks

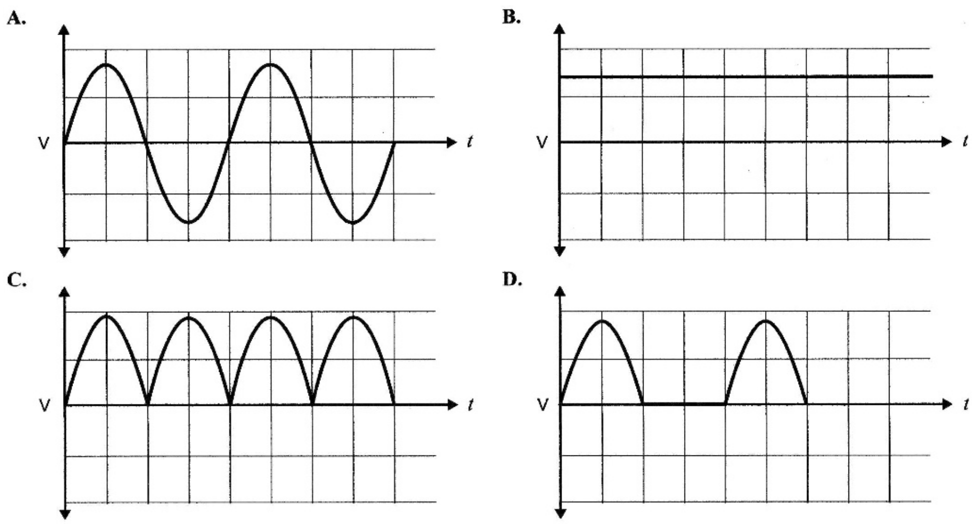
Question 14

Describe the function of a commutator.

2 marks

Question 15

Which of the following best represents the output of a DC generator?



2 marks

Area 1 - continued

Basilio has brought an electrical device back from overseas which functions at a voltage of 120V RMS and power rating of 60W. He has a transformer available with 60 turns in its secondary winding which he plans to use to step down the mains voltage from 240V RMS to 120V RMS.

Question 16

For Basilio's plan to be a success, how many turns must be in the primary winding of the transformer?

2 marks

Question 17

What is the peak current in the secondary coil of the transformer?

A

2 marks

Question 18

Would the transformer operate successfully if connected to a 240V DC supply?
Explain your answer.

____
____
____
____
____

3 marks

Area 1 – continued

AREA 2 – Interactions of light and matter

Specific Instructions for Area 2
Area 2 consists of 14 questions.
There are 30 marks available for Area 2.

Specific data for Area 2:
Planck's constant = 6.63×10^{-34} Js
Charge on an electron = 1.6×10^{-19} C
Speed of light = 3.0×10^{8} m/s
Mass of an electron = 9.1×10^{-31} kg

Goran and Mladen are understandably fascinated by Physics and want to investigate the photoelectric effect. They set up an apparatus where light of a single frequency is directed onto a clean metal plate, P, inside an evacuated tube, as shown in Figure 1 below, and measure the kinetic energy of any electrons ejected from the surface.
Initially they observe no ejected electrons, so Mladen increases the intensity of the incident light to see if this will lead to the ejection of electrons.

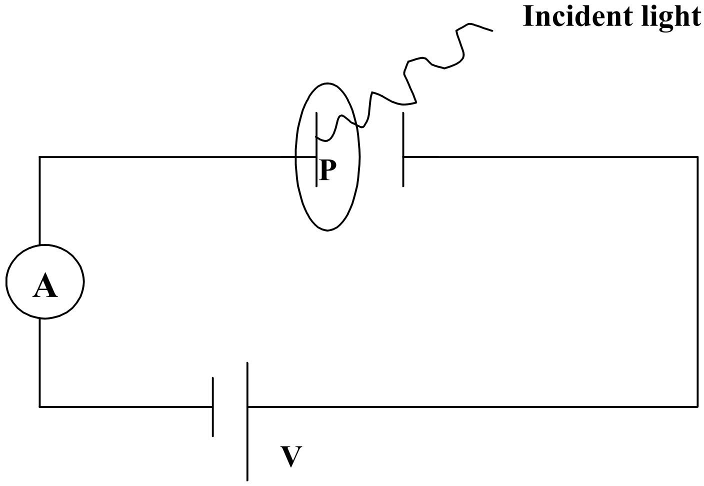


Figure 1

Question 1

Will increasing the intensity of incident light cause electrons to be ejected? Explain your answer.

____
____
____
____
____

3 marks
Area 2 - continued

Goran is thrilled with the results of the previous experiment and decides to investigate further, repeating the experiment using various different frequencies of incident light to see if this affects the kinetic energy of the ejected electrons.
As he varies the frequency of the incident light, he records the maximum kinetic energy of the electrons ejected from the surface of the metal.

Question 2

Describe what is likely to happen to the kinetic energy of the ejected electrons as Goran shines light of different frequencies onto the metal plate, and state whether these observations support the wave or the particle model of light.

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____
____
____
____
____

3 marks

Goran presents his results for maximum kinetic energy of ejected electrons vs frequency of incident light graphically, as shown in Figure 2.

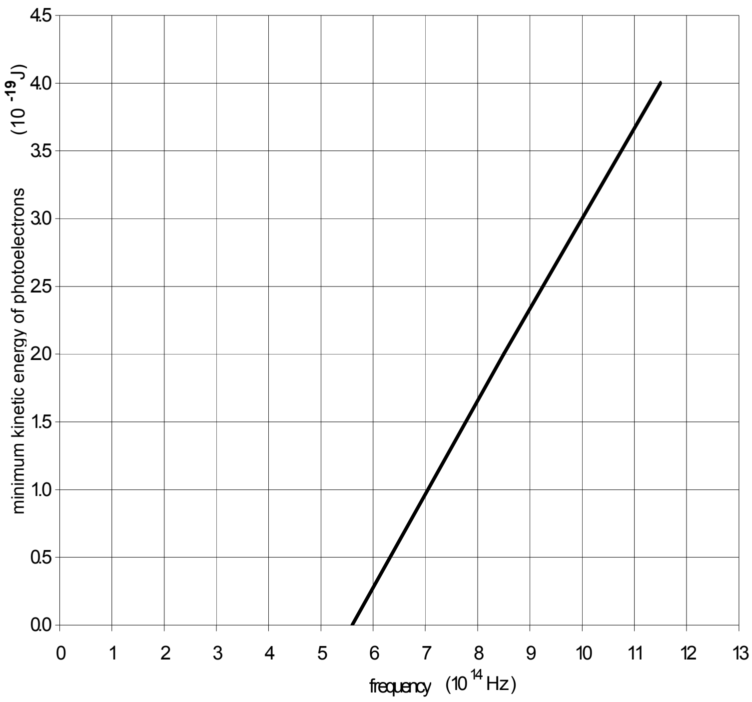

Figure 2

Area 2 - continued

Question 3

From this graph, determine the value of Planck's constant, *h*. (You must show your working.)

Js

2 marks

Question 4

What is the threshold frequency for this metal?

Hz

2 marks

Question 5

What is the photon energy corresponding to this threshold frequency?

J

2 marks

Question 6

What would be the minimum retarding voltage required to stop an electron of kinetic energy 4.2×10^{-19} J from crossing the evacuated tube?

V

2 marks

Question 7

Define the term "work function" as it applies to the photoelectric effect.

2 marks

In a particular trial, Mladen directs light of frequency 2×10^{15}Hz at the plate, and measures the number of photoelectrons striking the metal plate P as 3.2×10^{14} s^{-1}.

Area 2 - continued

Question 8

Calculate the energy (in joules) arriving each second at P.

J/s

2 marks

As Goran and Mladen are enjoying a well-earned lunch, Mladen looks at his can of drink and has a brainwave. He decides to replace the metal plate in the apparatus with one made from a different type of metal, then repeat his measurements and plot a new graph.

Question 9

Which **one or more** of the following features of the graph in Figure 2 could alter significantly if the metal is changed?

A the gradient of the line
B the point at which the line intersects the x – axis
C the shape of the graph – it could become a parabola
D the point at which the line will intersect the y - axis
E none of the above

2 marks

Goran and Mladen are now joined by their friend Milijana and are introducing her to the joys of Physics by discussing the energy levels of mercury, the first several of which are shown in Figure 3 below.

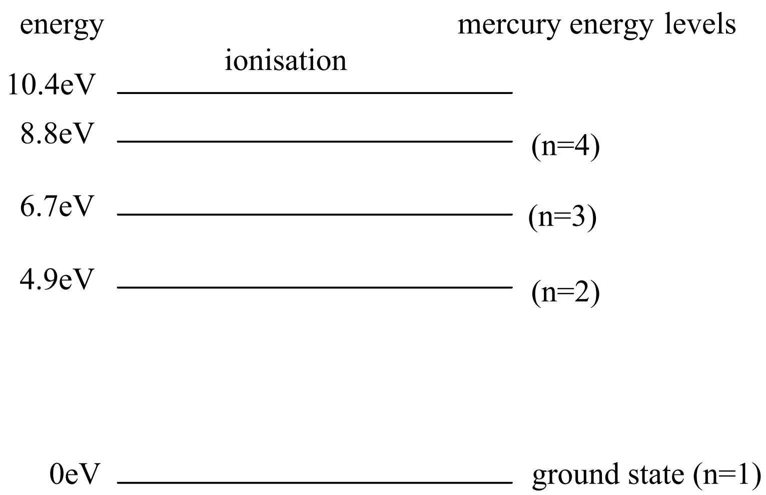

Figure 3

Area 2 – continued

Question 10

Calculate the wavelength of the photon of light emitted as an atom of mercury makes the transition from the second excited state (n=3) to ground state.

m

2 marks

Question 11

Calculate the momentum of the photon of light produced in Question 5.

Ns

2 marks

Milijana is, of course, tremendously excited and eager to learn more, so Mladen and Goran oblige by shining red laser light of frequency 4.7 x 10^{14} Hz through a single slit, obtaining the diffraction pattern shown in Figure 4 below.

Figure 4

Question 12

Explain how the dark and light bands in Figure 4 are produced.

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____

____

2 marks

Question 13

What is the approximate size of slit which could have caused this pattern?

m

2 marks

Question 14

Describe what would happen to the pattern if they replaced the red laser with a blue one.

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____

2 marks

Area 2 - continued

AREA 3.1 – Synchrotron and its applications

Specific Instructions for Area 3.1

Area 3.1 consists of **10 questions**.
Answer all questions on the multiple choice answer sheet provided.
Marks are indicated at the end of each question. A total of **20 marks** is available for area 3.1.

Specific data for Area 3.1:
Charge on an electron = 1.6×10^{-19} C
Mass of an electron = 9.1×10^{-31} C
Planck's constant = 6.63×10^{-34} Js
Speed of light = 3.0×10^{8} m/s

Dennis, Philip and Bosley are the proud scientists in charge of a state of the art synchrotron.

Question 1

Which one of the following sequences best gives the order in which electrons pass through the synchrotron?

A. storage ring, linac, booster ring, beam line
B. electron gun, booster ring, storage ring, linac
C. electron gun, linac, booster ring, storage ring
D. linac, storage ring, booster ring, beam line

2 marks

Dennis claims that the synchrotron produces a superior source of X-rays as compared to those produced by an X-ray tube.

Question 2

Two advantages of using a synchrotron as a source of X-rays as opposed to an X-ray tube are:

A. The synchrotron rays are coherent and of lower intensity
B. Particular frequencies are easily chosen and the rays are less divergent
C. The synchrotron rays are unpolarised and less penetrating
D. A narrow spectrum of frequencies are available and the rays are incoherent

2 marks

Area 3.1 - continued

Bosley notices that there is a degree of energy loss occurring in the high-energy electrons in the circulating beam.

Question 3

Which one of the following statements **best** describes the most significant reason for this energy loss?

A. The bending and focusing magnets consume energy.
B. The vacuum in the ring is not completely zero.
C. Electrons lose energy because of synchrotron radiation.
D. Electrons collide with each other and lose energy.

2 marks

Question 4

The energy lost by the electrons is replenished by:

A. the bending magnets in the circular section
B. channeling the electrons into the booster ring
C. electric fields in the straight sections
D. reactions with positrons in the linac

2 marks

Philip notices a malfunction in the synchrotron. Normally, the injection magnet switches on only for a brief instant to direct the pulse of electrons into the circular booster ring. However, currently the magnet is still on after the pulse of electrons has completed one revolution of the booster ring, so the electrons now pass through the magnet a second time.

Question 5

Which one of the following would most likely occur due to this malfunction?

A. The electrons would be deflected outwards from the ring.
B. The electrons would continue around the ring.
C. The electrons would lose energy and continue around the booster ring at lower speed.
D. The electrons would be deflected inwards from the ring.

2 marks

Scotty has hired the synchrotron to perform an experiment in which X-rays are directed onto a sample and reflection observed and recorded. In one trial, an angle of reflection of 24^0 is observed for N=1. The wavelength of the X-rays is 0.13nm.

Area 3.1 - continued

Question 6

What is the atomic plane spacing of the material?

A. 1.9 Å
B. 1.6 Å
C. 2.3 Å
D. 3.4 Å **2 marks**

Question 7

What is the next angle of reflection for the material in the sample?

A. 43^0
B. 69^0
C. 34^0
D. 54^0 **2 marks**

Bragg diffraction can be used in a synchrotron to "tune" the wavelength of the beam line.

Question 8

This is achieved by:

A. using electrons of a very specific energy.
B. using a specific crystal and carefully selected angles.
C. choosing specific values for the bending and focusing magnets
D. using X-rays of a specific energy

2 marks

Question 9

When X-rays are scattered **elastically** from layers of atoms, this is known as:

A. Diffuse scattering
B. Compton scattering
C. Thompson scattering
D. Adamson scattering **2 marks**

Question 10

When X-ray photons interact in an **inelastic** manner with electrons, this is called:

A. Diffuse scattering
B. Compton scattering
C. Thompson scattering
D. Adamson scattering **2 marks**

Area 3.1 - continued

AREA 3.2 – Photonics

Specific Instructions for Area 3.2
Area 3.2 consists of 10 questions. **Answer all questions on the multiple choice answer sheet provided.**
There are 20 marks available for Area 3.2.

Specific data for Area 3.2:
Planck's constant = 6.63×10^{-34} Js
Speed of light in a vacuum = 3.0×10^{8} m/s
Charge on an electron = 1.6×10^{-19} C

Question 1

For the paragraph below, choose the set of answers which best completes the sentences.

A laser produces **(answer 1)** light. The input power to the laser produces **(answer 2)** in the electron energies of the gas atoms. The atoms are stimulated to release their energy by interacting with photons of **(answer 3)** energy.

A. coherent, population inversion, the same
B. broad spectrum, ionization, lower
C. multi-modal, coherence, higher
D. incoherent, diffraction, equal

2 marks

Question 2

The energy levels between which the excited electrons pass in a carbon dioxide laser are 0.11eV apart. The energy of a photon emitted from a carbon dioxide laser would be:

A. 3.54×10^{-20}J
B. 2.71×10^{-20}J
C. 4.52×10^{-20}J
D. 1.76×10^{-20}J

2 marks

Ngaire is experimenting with a particular optical fibre which has a core refractive index of 1.46 and cladding of refractive index 1.42, as shown in Figure 1.

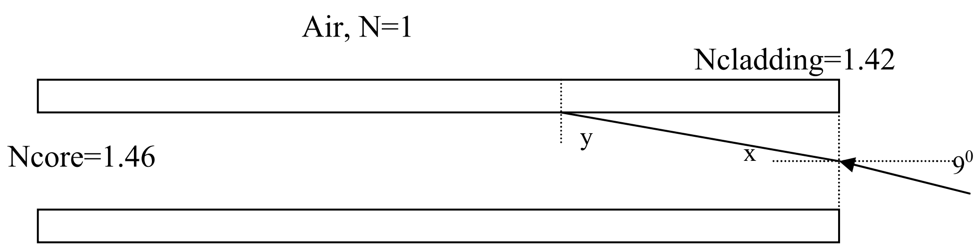

Figure 1

Area 3.2 – continued

Question 3

What is the critical angle for the core/cladding interface of the fibre in Figure 1?

A. 63^0
B. 77^0
C. 35^0
D. 9^0 **2 marks**

A ray of light enters the fibre at an incident angle of 9^0 as shown in Figure 1.

Question 4

What is the incident angle at the core-cladding interface?

A. 53^0
B. 84^0
C. 9^0
D. 27^0 **2 marks**

Question 5

Which of the following changes would reduce modal dispersion of a fibre optic cable?

A. Use a thicker cladding
B. Use a smaller diameter fibre
C. Use a thinner cladding
D. Use a larger diameter fibre **2 marks**

Question 6

Which of the following would you choose for a transmission over a distance of 800km?

A. Multimode fibre with a laser diode light source
B. Multimode fibre with LED light source
C. Single-mode fibre with LED light source
D. Single-mode fibre with a laser diode light source **2 marks**

Area 3.2 - continued

Loss of light as it travels down optical fibres may occur due to Rayleigh Scattering.

Question 7

Which of the following wavelengths would suffer the least attenuation due to Rayleigh Scattering?

A. 1500nm
B. 750nm
C. 360nm
D. 1200nm **2 marks**

Question 8

One advantage of a graded-index fibre over a step-index fibre is that it reduces the effect of:

A. material dispersion
B. Rayleigh scattering
C. absorption
D. modal dispersion **2 marks**

Question 9

For the paragraph below, choose the set of answers which best completes the sentences.

A fibre-optic cable is composed of two concentric layers called the core and the cladding. The refractive index of the core is always **(answer 1)** the index of the cladding. In a single-mode fibre, light enters the cable and travels along a path which is the **(answer 2)** order mode. In this mode, chromatic dispersion and attenuation are **(answer 3)**.

A. less than, highest, reduced
B. greater than, lowest, reduced
C. equal to, lowest, increased
D. greater than, highest, increased **2 marks**

Question 10

A laser source is superior to a LED source in a fibre-optic system because it causes less:

A. modal dispersion
B. material dispersion
C. Rayleigh scattering
D. absorption **2 marks**

Area 3.2 - continued

AREA 3.3 – Sound

Specific Instructions for Area 3.3

Area 3.3 consists of **10 questions**.
Answer all questions on the multiple choice answer sheet provided.
A total of **20 marks** is available for Area 3.3.

Specific data for Area 4:
Speed of sound in air = 330m/s
Area of a sphere is $4\pi r^2$

Lil is currently performing the role of Mimi in Puccini's La Boheme, and sings a beautiful, pure note. The resultant sound wave travels outwards from her to the audience, who are thrilled by her stunning voice.
The displacement of air molecules from their mean positions varies with the distance from Lil at a given time. This variation, in arbitrary units, is shown in Figure 1 below.

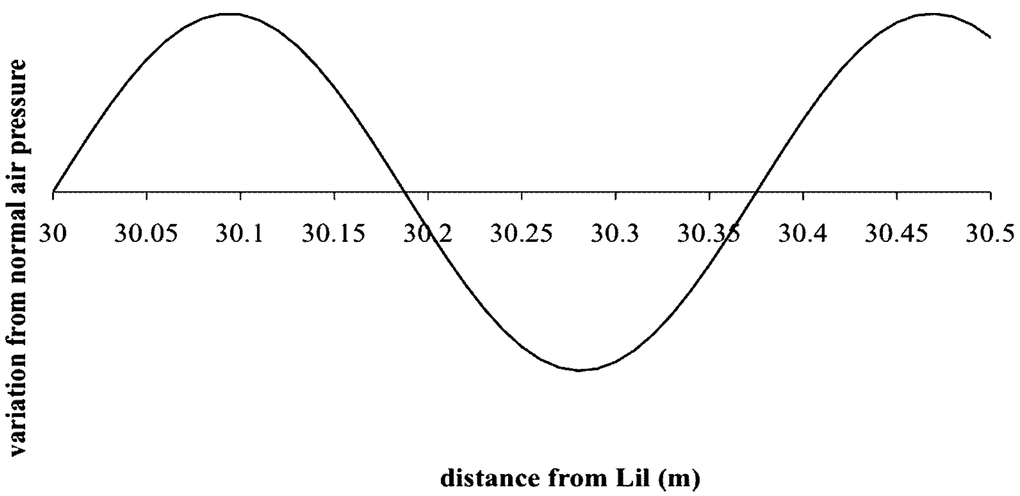

Figure 1

Question 1

What is the frequency of Lil's beautiful note?

A. 440Hz
B. 880Hz
C. 660Hz
D. 1200Hz

2 marks
Area 3.3 – continued

Question 2

Sound is best described as a:

A. transverse wave
B. electromagnetic wave
C. circular wave
D. longitudinal wave

2 marks

Question 3

How long would it take for 3000 complete cycles of the sound wave produced by Lil to be completed?

A. 6.2 secs
B. 6.9 secs
C. 3.4 secs
D. 4.7 secs

2 marks

Question 4

A particle of dust is floating in the air directly in front of Lil's mouth.
Which of the following best describes its motion?

A It remains at rest
B It vibrates vertically up and down at the frequency of the sound wave
C It travels horizontally away from Lil, in the direction of the sound wave
D It vibrates horizontally back and forth at the frequency of the sound wave

2 marks

Lil's vocal tract can be modelled as a closed pipe.
The length of the pipe is altered by changing the position of the larynx.

Question 5

What is the length, L, of the pipe required to produce Lil's note as shown in Figure 1?

A. 9.4cm
B. 12.3cm
C. 7.6cm
D. 3.5cm

2 marks

Area 3.3 – continued

Question 6

What is the next highest frequency above the fundamental in Question 1 at which Lil's vocal tract will resonate?

A. 1760Hz
B. 880Hz
C. 2640Hz
D. 2400Hz **2 marks**

One of the ushers in the theatre is listening to the La Boheme performance through a gap in a slightly opened door.

Question 7

For the paragraph below, choose the set of options which best completes the paragraph correctly.

When a sound wave from the performance travels through the gap, **(answer 1)** occurs. High pitched (frequency) instruments such as flutes experience (**answer 2)** spreading than lower pitched instruments. As the size of the gap decreases, the angle of spreading will **(answer 3)**.

A. constructive interference, less, increase
B. constructive interference, more, decrease
C. diffraction, less, increase
D. diffraction, more, decrease **2 marks**

As Lil sings, the sound energy radiates out from her in all directions. One clever audience member, Tanya, has brought along a sound intensity meter and measures the sound intensity produced by Lil's voice at her position at a particular moment as 4×10^{-5} Wm^{-2}.

Question 8

What would be the **increase** in sound intensity level for an audience member sitting at a position exactly half of Tanya's distance from Lil at that moment?

A. 1.2×10^{-4} Wm^{-2}
B. 1.6×10^{-4} Wm^{-2}
C. 4×10^{-5} Wm^{-2}
D. 8×10^{-5} Wm^{-2}

2 marks

Area 3.3 - continued

Question 9

What is the corresponding sound intensity level of Lil's singing at Tanya's position at that moment?

A. 43dB
B. 68dB
C. 57dB
D. 76dB

2 marks

Tanya rings a friend after the performance to tell them how fabulous Lil's singing was.

Question 10

Based on your knowledge of microphones, the best microphone for use in a mobile phone would be:

A. crystal
B. dynamic
C. electret-condenser
D. velocity?

2 marks

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PHYSICS Unit 4

MULTIPLE CHOICE ANSWER SHEET

Colour the box after the letter corresponding to your answer.

3.1 Synchrotron & its Applications					3.2 Photonics				
1.	A☐	B☐	C☐	D☐	1.	A☐	B☐	C☐	D☐
2.	A☐	B☐	C☐	D☐	2.	A☐	B☐	C☐	D☐
3.	A☐	B☐	C☐	D☐	3.	A☐	B☐	C☐	D☐
4.	A☐	B☐	C☐	D☐	4.	A☐	B☐	C☐	D☐
5.	A☐	B☐	C☐	D☐	5.	A☐	B☐	C☐	D☐
6.	A☐	B☐	C☐	D☐	6.	A☐	B☐	C☐	D☐
7.	A☐	B☐	C☐	D☐	7.	A☐	B☐	C☐	D☐
8.	A☐	B☐	C☐	D☐	8.	A☐	B☐	C☐	D☐
9.	A☐	B☐	C☐	D☐	9.	A☐	B☐	C☐	D☐
10.	A☐	B☐	C☐	D☐	10.	A☐	B☐	C☐	D☐

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PHYSICS Unit 4

MULTIPLE CHOICE ANSWER SHEET

Colour the box after the letter corresponding to your answer.

3.3 Sound

1. **A☐ B☐ C☐ D☐**

2. **A☐ B☐ C☐ D☐**

3. **A☐ B☐ C☐ D☐**

4. **A☐ B☐ C☐ D☐**

5. **A☐ B☐ C☐ D☐**

6. **A☐ B☐ C☐ D☐**

7. **A☐ B☐ C☐ D☐**

8. **A☐ B☐ C☐ D☐**

9. **A☐ B☐ C☐ D☐**

10. **A☐ B☐ C☐ D☐**

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SUGGESTED SOLUTIONS TO 2010 PHYSICS UNIT 4 TRIAL EXAM

AREA OF STUDY 1 - Electric Power

Question 1

Use the right hand slap rule and assume the Earth's magnetic field points north. Current is down the rod. Thus, the force will be toward the **west.** **D ANS**

Question 2

F=BIl
Thus, $F = (30 \times 10^{-6})(2 \times 10^{4})(12)$
So, B = **7.2T ANS**

Question 3

The rod is no longer perpendicular to the magnetic field, and so the force will be less than before.
Thus, **C ANS**

Question 4

P = VI (using RMS values given)
Thus, 48 = 240 I
I = **0.2A RMS ANS**

Question 5

Each branch of the parallel circuit has the same resistance, thus 1/3 of the current will run through each branch.
Thus, 0.2/3 = **0.067A RMS ANS**

Question 6

240V must be lost across each parallel path, so every globe receives 1/6 of this voltage.
Thus, V across each globe is 240/6 = **40V ANS**

Question 7

Can use either $P = VI = 40 \times 0.067 = 2.7$
OR P total/18 = 48/18 = **2.7W ANS**

Question 8

The middle row of lights is now an open circuit, but the other branches still function and receive the same voltage as before.
Thus, **D ANS**

Question 9

In this orientation, the coil is parallel to the field and thus area perpendicular to the field is 0.
Thus, Flux ϕ = BA = 0 Wb ANS

Question 10

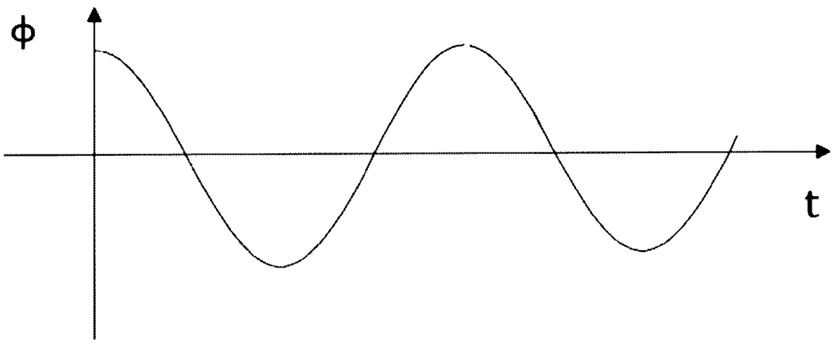
The coil is now perpendicular to the field.
Thus, Flux ϕ = BA = 0.3 x (0.4 x 0.5) = $0.06 = 6 \times 10^{-2}$ Wb ANS

Question 11

$\varepsilon = n\Delta\phi/\Delta t$
During rotation, flux changes from maximum 0.06Wb to 0Wb, thus $\Delta\phi = 0.06$
f = 50Hz, meaning 50 rotations per second.
Thus, period, T = 1/50 for one rotation, so time for a quarter turn is 1/50 x 1/4=1/200=0.005 secs
Magnitude of $\varepsilon = n\Delta\phi/\Delta t = 12(0.06/ 0.005) =$ **300 V ANS**

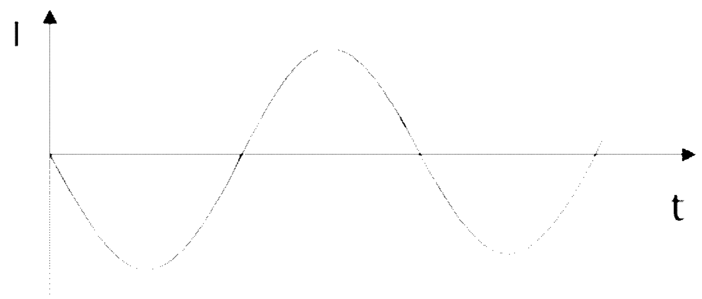
Question 12

The flux will alternate between maximum (coil perpendicular to the field) at t=0 and minimum values (coil parallel to the field) in a sinusoidal fashion.



Question 13

Since $\varepsilon = n\Delta\phi/\Delta t$ the emf should vary as the gradient of the flux (ie: a sine graph starting at a minimum). Also, by Lenz's Law, as flux decreases through the coil, current will flow from B to A (negative) to try to oppose the change and maintain the flux in the coil.
Thus, a negative sine graph starting at a minimum.



Question 14

P = VI
Thus, 2000 = 240I
So, I = **8.3A ANS**

Question 15

Ploss = $I^2R = (25)^2 \times 1.8$ = **1125W = 1.1kW ANS**

Question 16

Vloss = IR = 30 x 1.8 = 54V
Thus, voltage at house = Vtotal – Vloss = 240 – 54 = **186V ANS**

Question 17

Since P loss in wires is given by P loss = I^2R, the lower I can be made, the smaller the power loss (R is fixed once the lines are up). A low I corresponds to a high V (by P = VI), and thus transmission occurring at a relatively high V and low I reduces power losses in the transmission wires.

AREA OF STUDY 2 – Interactions of Light and matter.

Question 1

$E = hc/\lambda = (6.63 \times 10^{-34})(3\times10^{8}) / (540\times10^{-9})$
$= 3.68 \times 10^{-19}$ J = $(3.68 \times 10^{-19})/(1.6\times10^{-19})$ = **<u>2.3eV ANS</u>**

Question 2

Work function of caesium is 2.1eV – the minimum energy required to remove an electron from the surface of the metal.
Thus, the maximum KE of ejected electrons will be 2.3 – 2.1 = **0.2eV ANS**

Question 3

$KE = \frac{1}{2} mv^2$
Thus, $(2.8)(1.6\times10^{-19}) = \frac{1}{2}(9.1 \times 10^{-31}) v^2$
So, v = **9.9×10^5 m/s ANS**

Question 4

<u>Dominica is incorrect.</u>
In the photoelectric effect, a photon of light gives up all of its energy to an electron in the metal, possibly giving it enough energy to break free of the surface of the metal. If the photon's energy is great enough, any excess energy above that required for the electron to break free appears as kinetic energy of the electron.
Increasing the intensity of light has no effect on the KE of the electrons. This is because the energy given to each electron depends on the energy, and hence the frequency, of the incident light. If a frequency above the threshold is used, then increasing the intensity of the light will result in a greater number of photons reaching the metal, but the frequency of the light, and thus the energy of the photons, will remain unchanged. Thus, increasing the intensity of the light (for a frequency above the threshold) will result in a greater number electrons being emitted, but will have no effect on the kinetic energy of these electrons.
These observations support the particle model of light, since with a wave model the incident energy would build up until electrons were released, whereas in reality light of a specific minimum frequency is required for electron ejection.

Question 5
The path difference to the fifth bright band is $5\lambda = 5(632 \times 10^{-9})$ = **3.2×10^{-6}m ANS**

Question 6
Young's experiment supports the **wave model of light**. The interference pattern produced on the screen is evidence of constructive and destructive interference, which is the result of the superposition of waves as they meet in phase or out of phase.
A dark region is created by a region of destructive interference (nodes), where the superposition of light waves causes cancelling (waves out of phase). The bright regions are regions of constructive interference where an antinode is formed when the waves meet in phase and reinforce.

Question 7

W = λL/d, where W is the fringe spacing, λ is the wavelength of the laser light, d is distance between the slits, and L is distance from the slits to the wall.
Thus, in order for the spacing of the fringes to be smaller (pattern of fringes closer together), W must be smaller - we must either **decrease** λ or L, or **increase** d.
So, the only correct possibility is **C ANS**

Question 8

The frequency of blue light is higher than the frequency of red light, and thus λ(blue) is shorter than λ(red).
Since amount of diffraction ≈ λ/w, blue light (with its shorter wavelength) will undergo less diffraction than red, and thus the diffraction pattern for blue light would be less spread.

Question 9

Diffraction is a wave property, so this is the **best** explanation.
Thus, **B ANS**

Question 10

This is **best** explained by x-rays and electrons having the same wavelength (diffraction being a wave property). Thus, **D ANS**

Question 11

$E = hc/\lambda = (6.63 \times 10^{-34})(3\times10^{8}) / (250\times10^{-12})$
$= 3.96 \times 10^{-16}$ J = $(7.96 \times 10^{-16})/(1.6\times10^{-19}) = 4972 =$ **5keV ANS**

Question 12

If the patterns are identical, so are the wavelengths.
Thus, use λ = 250pm
p = h/λ.
$= (6.63 \times 10^{-34}) / (250 \times 10^{-12})$
$= 2.7 \times 10^{-24}$ kgm/s ANS

Question 13

Photons do not have charge or mass.
Thus, **A and B ANS**

AREA OF STUDY 3.1 – Synchrotron and its applications

Question 1

The **storage ring** is a donut-shaped ring into which the booster ring channels electrons. The electrons orbit the ring for hours at a time, at speeds close to that of light, with a series of magnets making them bend around corners as they travel through the ring. As the electrons change direction, they release **synchrotron radiation**. **D ANS**

Question 2

The **circular booster ring** uses an accelerating, or radio frequency (rf) chamber through which electrons pass every time they orbit the ring, giving them a boost of energy as they continue to accelerate around their circular path. **B ANS**

Question 3

The function of the linear accelerator (**linac**) in the synchrotron is to accelerate particles to speeds close to the speed of light. **A ANS**

Question 4

The bending magnets cause the electron paths to bend and thus confine them to a circular path within the storage ring. **C ANS**

Question 5

Total energy lost by the incident x-ray is $3.2 + 27 = 30.2$eV
Energy of incident photon, $E = hf = hc/\lambda$
Thus, $E = (6.63 \times 10^{-34})(3 \times 10^{8}) / (0.3 \times 10^{-9}) = 6.63 \times 10^{-16}$J = 4143.75eV
Energy of scattered photon = $4143.75 - 30.2 = 4113.55$eV = 6.582×10^{-16}J
$6.582 \times 10^{-16} = hc/\lambda = (6.63 \times 10^{-34})(3 \times 10^{8})/\lambda$
So, $\lambda = 3.02 \times 10^{-10}$m = 0.302 nm Thus, **B ANS**
(Note: the interaction was all but insignificant for this high energy x-ray)

Question 6

Elastic scattering from layers of atoms is known as **Thomson scattering.**
X-ray photons can also interact with electrons and transfer some of their energy to the electron, resulting in the X-ray photon emerging with a longer wavelength (less energy) and the ejection of an electron. These collisions are **inelastic** and are referred to as **Compton scattering**.
Diffuse scattering occurs when X-rays are directed at a sample with a disordered, random orientation of molecules in its array, producing a pattern of circular rings on the detector.
Rasheed scattering does not exist.

This is an example of **Compton Scattering.** **B ANS**

Question 7

KE = ½ mv^2 = eV
= $(1.6 \times 10^{-19})(2.1 \times 10^3)$
= **3.4×10^{-16} J**
Thus, **A ANS**

Question 8

3.4×10^{-16} = ½ mv^2 = ½ $(9.1 \times 10^{-31})v^2$
Thus, v = **2.7×10^7 m/s ANS**
So, B ANS

Question 9

F = qvB = evB = $(1.6 \times 10^{-19})(2.7 \times 10^7)(2.5 \times 10^{-3})$
Thus, F = **1.1×10^{-14}N ANS**
So, **D ANS**

AREA OF STUDY 3.2 – Photonics

Question 1

$E = hf = hc/\lambda$
Thus, $1.9(1.6 \times 10^{-19}) = (6.63 \times 10^{-34})(3 \times 10^{8}) / \lambda$
So, $\lambda = 6.5 \times 10^{7}$m = 650 nm   Thus, **C ANS**

Question 2

Wavelength does not change, as it is set by the energy gap, which is constant for a particular LED. Current will increase, as V = IR, even if R is variable. Thus, **C and D ANS**

Question 3

Decreasing band gap energy corresponds to decreasing photon energy and hence increasing photon wavelength. Thus, order will be blue, green, red. **D ANS**

Question 4

Red laser light is superior to red LED light in that it is monochromatic, less divergent, coherent and more intense. Thus, the only correct answer is **A ANS**

Question 5

The best explanation for the peak at point X is a loss of signal, probably due to resonance caused by impurities (eg: water contamination). Thus, **C ANS**

Question 6

Minimum point read from the graph is 1300 nm. Thus, **B ANS**

Question 7

Wavelengths with least attenuation are 1050 nm and 1300 nm.

$v = f\lambda$
$3 \times 10^{8} = f \times 1050\times10^{-9}$ So, $f = 2.86 \times 10^{14}$ Hz
$3 \times 10^{8} = f \times 1300\times10^{-9}$ So, $f = 2.31 \times 10^{14}$ Hz

Thus, **C ANS**

Question 8

Long wavelengths tend to travel faster in glass than shorter ones, so the IR pulse will arrive earlier. Thus, **A ANS**

Question 9

Rayleigh scattering dominates at these wavelengths and scattering increases as the wavelength decreases, so there will be more attenuation for the RD pulse. Thus, **D ANS**

AREA OF STUDY 3.3 – Sound

Question 1

Sound level = 10log (I / I_O) , where $I_O = 1.0 \times 10^{-12}$ Wm^{-2}

Thus, sound level = 10 log ($4 \times 10^{-3} / 1.0 \times 10^{-12}$) = **96 dB So, B ANS**

Question 2

$I = 4 \times 10^{-3}$ Wm^{-2}

Power = Intensity x area (of a sphere in this case)

= (4×10^{-3}) x $4\pi r^2$ = (4×10^{-3}) x $4\pi (6)^2 \approx$ **1.8 W Thus, A ANS**

Question 3

4 m away, area = $4\pi r^2 = 4\pi(4)^2 = 201$ m^2

Thus, I = P/A = 1.8/201 = 9×10^{-3} W/m^2 ANS

So the intensity level = 10 log (9×10^{-3} / 1.0×10^{-12}) = 99.5 dBANS

Thus, the increase is 99.5-96 = **3.5 dB ANS**

Alternatively:

I increased by a factor of $8.96 \times 10^{-3}/(4 \times 10^{-3})$ = 2.25 times

Thus, the corresponding increase in intensity level is:

10 log (2.25) = **3.5dB ANS**

Question 4

Cass is likely to hear an alternating series of loud and soft intensities of sound, caused by interference of the two in-phase waves from the two speakers.

At points where the path difference of the waves travelling from the two speakers is a whole number of wavelengths (p.d. = $N\lambda$, where N is an integer), constructive interference occurs and a loud sound is heard (antinode). At points where the waves are half a cycle out of phase (path difference = $(N-1/2)\ \lambda$) destructive interference occurs and a very soft sound is heard (node).

Cass is walking along a progression of nodes and antinodes, and thus hears a series of loud and soft sounds. Thus, **B ANS**

Question 5

A crystal microphone employs the piezoelectric effect. Thus, **D ANS**

Question 6

An electret-condenser microphone employs capacitance. Thus, **B ANS**

Question 7

A dynamic microphone employs the electromagnetic induction. Thus, **A ANS**

Question 8

$v = f\lambda$.
Thus, $330 = 100\lambda$
So, **$\lambda = 3.3$ m ANS**

Question 9

Low frequency sounds diffract more easily (longer wavelength, amount of diffraction is proportional to λ/w). Thus higher frequency sounds from the central speaker have shorter wavelengths and thus diffract less around the TV and are thus less audible to Al and Oscar.