

MYP MAY 2016

PHYSICS ON-SCREEN EXAMINATION

Exemplar Marked Candidate Responses

This document contains exemplar material which demonstrates how the markscheme was applied to two student responses for the May 2016 session. Teachers should consider the application of the markscheme and in particular the assessment of longer, open ended responses. Teachers may wish to mark the student response themselves using the published markscheme and then compare their marking to the standard demonstrated in this document.

Question 1 (5 marks)

The following table contains information that can be used to describe mass or weight.

Question 1a (2 marks)

Select the correct option to complete the table.

	Mass	Weight
Units	newton	kilogram
Type of quantity	size and direction	size only
Effect of gravitational field strength	independent of gravitational field strength	dependent on gravitational field strength

0/2 Only one row correct so no mark.

Question 1b (2 marks)

The table below contains information about four planets in the solar system. Using this information, select the **three** unnamed planets and complete the table.

	Relative mass compared to Earth	Orbital period/ Year	Number of moons	Main gases in atmosphere	Are there any rings present?
Earth	1	1	1	N ₂ , O ₂ , Ar	No
Venus	0.82	0.62	0	CO ₂ , N ₂	No
Jupiter	17.2	164.8	14	H ₂ , He	Yes
Neptune	317.8	11.86	67	H ₂ , He	Yes

1/2

Question 1c (1 mark)

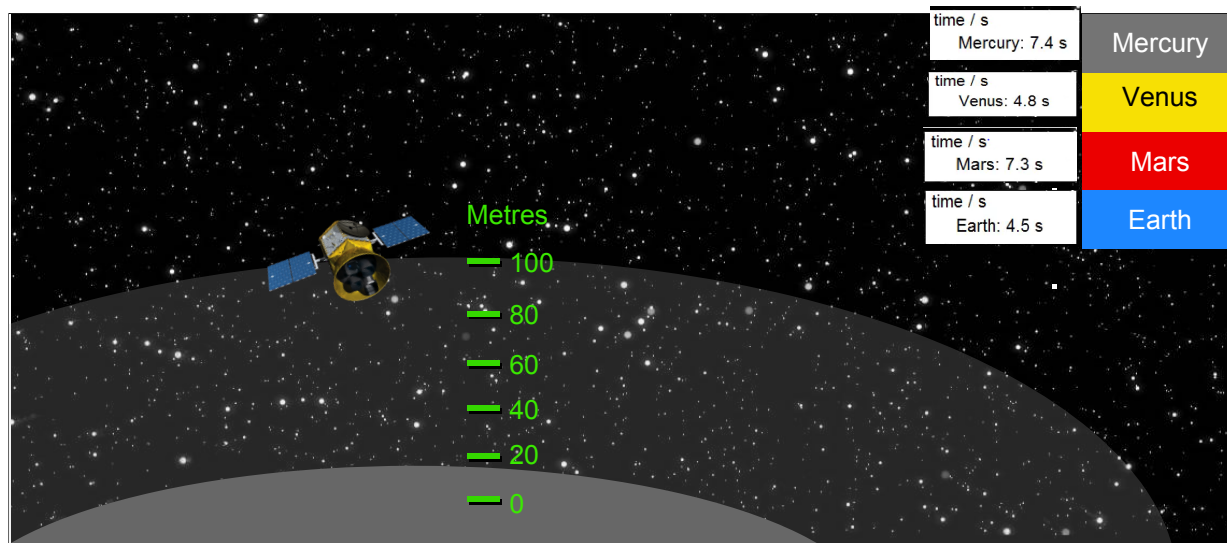
State why the outer planets tend to be colder than the inner planets.

Outer planets tend to be colder than inner planets because they are at a larger distance from the sun. Even though the Sun's heat is transferred by radiation, small asteroids, intercept the radiation, not allowing them to reach further planets. In addition, outer space is at a temperature of 0°K, and for this reason, being in the middle of space, and far away from the Sun, makes the planets much colder

0/1 While the student's initial answer is correct, they have gone on to make an incorrect statement which contradicts their earlier statement.

Question 2 (11 marks)

A robotic probe is sent into space to collect data from three of the four inner planets: Mercury, Mars and Venus. While passing close by each planet the probe drops a test object from a height of 100.0 m, the shape of the object ensures that any frictional forces are negligible over a fall of this distance.



Question 2a (3 marks)

Using the data you collected above, **calculate** the acceleration due to gravity on Mercury and Mars.

Mercury:

$$S = ut + 0.5gt^2$$

Acceleration due to gravity in mercury is:

$$0.5 \times (7.4 \times 7.4) = 27.38$$

$$100 \div 27.38 = 3.65230095$$

$$3.65 \text{ m/s}^2$$

Mars:

$$0.5 \times (7.3 \times 7.3) = 26.645$$

$$100 \div 26.645 = 3.753049353$$

acceleration due to gravity in mars is:

$$3.8 \text{ m/s}^2$$

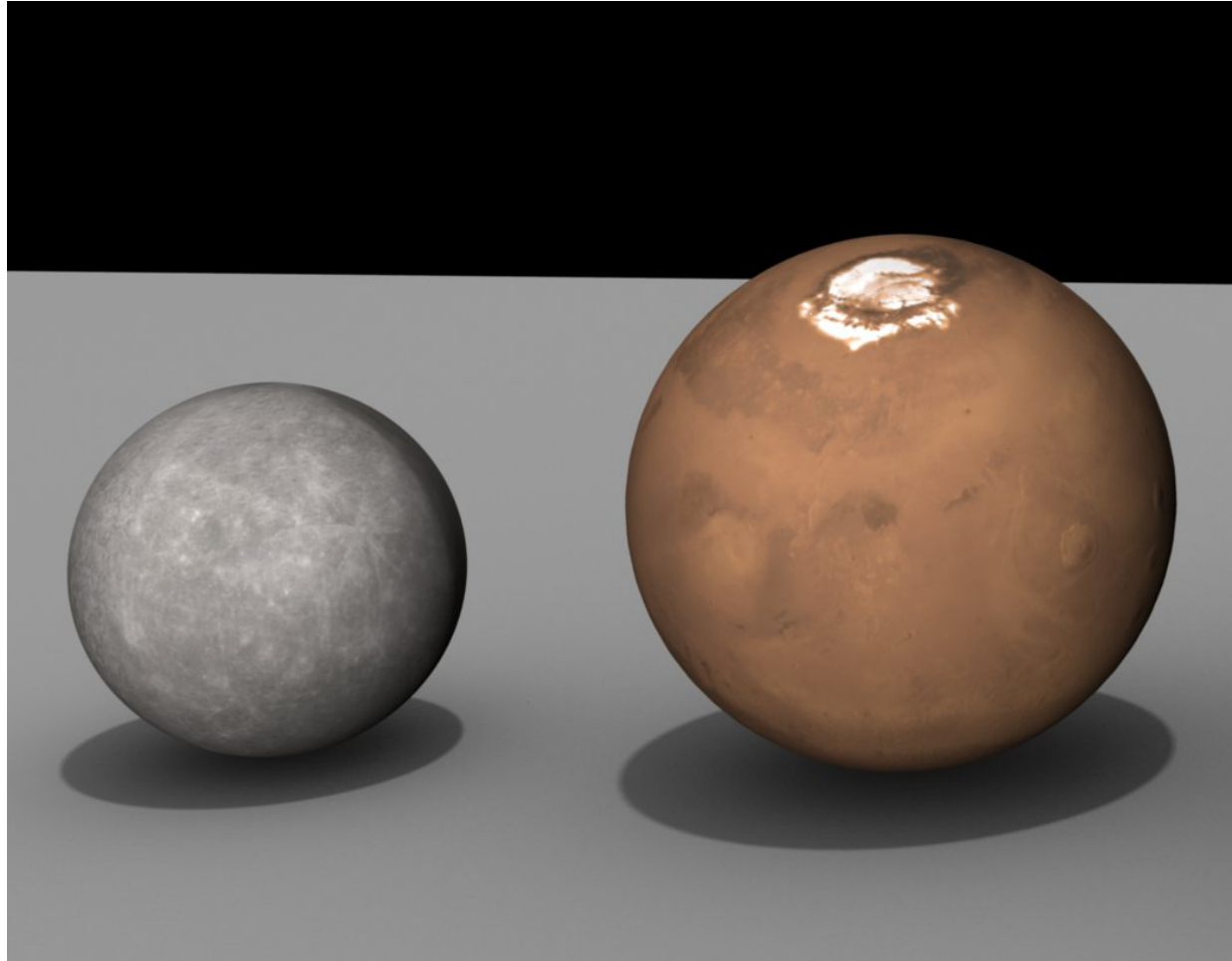
2/3 The candidate has given one answer to the correct number of sig figs but the other to three sig figs which is incorrect therefore the max marks available are 2.

The scientists receiving the data on Earth know that gravitational field strength (g) is proportional to a planet's density (ρ) and its radius (r).

gravitational field strength \sim density \times radius

$$g \sim \rho \times r$$

The radius of Mercury is about two thirds of the radius of Mars.



Mercury

Mars

Question 2b (2 marks)

Explain why Mars and Mercury can have almost the same value of g , if Mars has a much larger radius.

This is probably because of two reasons:
one could be that the density of mars is very high
the other could be that the density of mercury is very low

0/2 Mars has to have a lower density not higher in order for the relationship to be true.

Next, the space probe visits two of Jupiter's moons: Io and Ganymede.

The experiment is repeated and again a test object is dropped from a height of 100.0 m.

The gravitational field strength of Io = 1.8 N kg^{-1} .

The gravitational field strength of Ganymede = 1.4 N kg^{-1} .

The test object has a mass of 20 kg.

Question 2c (3 marks)

Use information from the formula sheet to **calculate** the gravitational potential energy (E_p) of the test object before it is dropped over Io.

$$PE = mgh$$

$$PE = 3.6 \text{ KJ}$$

3/3 Although the numbers are not put into the equation, by giving the equation and having the correct final answer it is clear that the candidate has used the equation correctly.

All of the test object's gravitational potential energy (E_p) transforms to kinetic energy before hitting the surface of the moons.

Question 2d (3 marks)

The test object travels faster before hitting the surface of Io than it does before hitting the surface of Ganymede. **Explain** this observation.

THIS IS BECAUSE THE FIELD STRENGTH OF IO IS GREATER THAN OF GANYMEDE. THEREFORE, ACCELERATION DUE TO GRAVITY IS HIGHER OVER THERE.

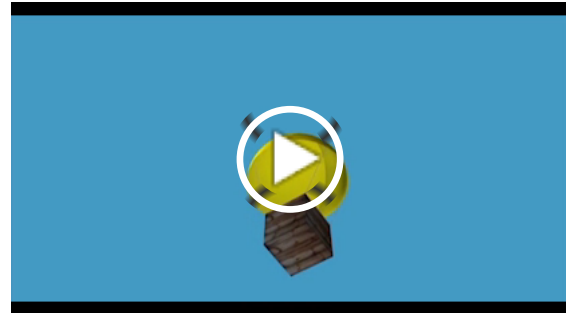
0/3 It is not clear whether "over there" is referring to Io or Ganymede

Question 3 (11 marks)

When the space probe in Question 2 is investigating acceleration, air resistance is negligible.

On Earth, a parachute can be used to increase air resistance.

The maximum speed a falling object reaches is known as the terminal velocity.



Question 3a (2 marks)

Some students perform an investigation into the terminal velocity of a simple parachute. One of the students wants to investigate how the area of the parachute affects its terminal velocity.

Suggest one piece of equipment that the student will need to perform this experiment.

Equipment:

To be able to see how much time it takes for the object to reach its terminal velocity.

2/2 Complete answer.

Question 3b (3 marks)

Suggest and explain a hypothesis for this experiment.

The greater the parachute's area is, the slower the parachute will be able to reach its terminal velocity. This can be explained by the fact that more air particles will be hitting the parachute if the area is greater.

0/2 Mars has to have a lower density not higher in order for the relationship to be true.

Question 3c (3 marks)

State one variable that the student will need to control. **Describe** how this variable should be controlled and why it should be controlled.

Variable

This is not a control variable.

How the variable should be controlled

This would be changed therefore it is not a control variable.

Why the variable should be controlled

0/3

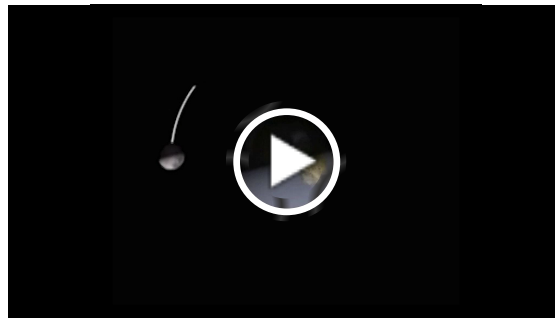
Question 3d (3 marks)

Explain what results the student will need to collect to ensure that they have sufficient relevant data.

0/3 No range is given, or repeats.

Question 4 (3 marks)

The first animation shows the Moon orbiting the Earth.



The second animation shows how the Moon looks each day, when viewed from the Earth over a complete month.



Question 4a (2 marks)

Using the information from both animations, **describe** why the appearance of the Moon changes over a month.

The appearance of the moon varies and depends on its position to the sun, thus making it look it like it has a dark and light side.

0/2 It is not due to the position the moon has to the sun that makes it appear different to the Earth.

Question 4b (1 mark)

The Moon affects the tides on Earth. **Identify** the force that produces this effect.

The force that produces this effect is gravity.

1/1

Question 5 (2 marks)

In the 1950s, cosmologists proposed the "steady-state" theory to explain certain aspects of the universe after it was observed to be expanding. This theory states that:

- the universe has no beginning or end
- the temperature of the universe has always been constant and will not change in the future
- as the universe expands, new matter is created and the density of the universe remains constant.

Outline two ways in which this theory is different to the "big-bang" theory.

The big bang theory explains that the universe did indeed have an initiation with a 'big bang' where the sun broke down into thousands of pieces, the bigger of which formed the planets we know of today.

The big bang theory states that the temperature of the universe is not constant.

1/2 The candidate is confused and mixing different ideas. Temperature is not constant is correct the first point about the initiation is a little confusing!

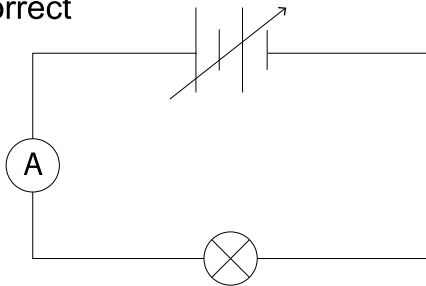
Question 6 (7 marks)

A student investigates an electrical circuit containing a variable power supply, an ammeter and a filament lamp (bulb) in which the current through the bulb can be changed.

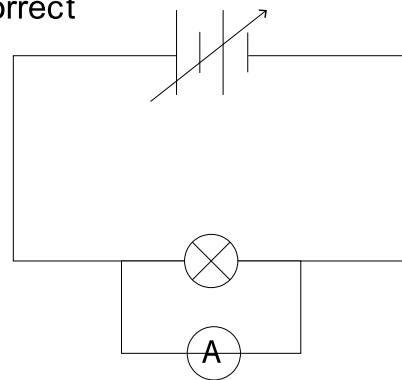
One of the circuit diagrams below is incorrect, the other circuit diagram is correct.

Question 6a (2 marks)

Correct



Incorrect



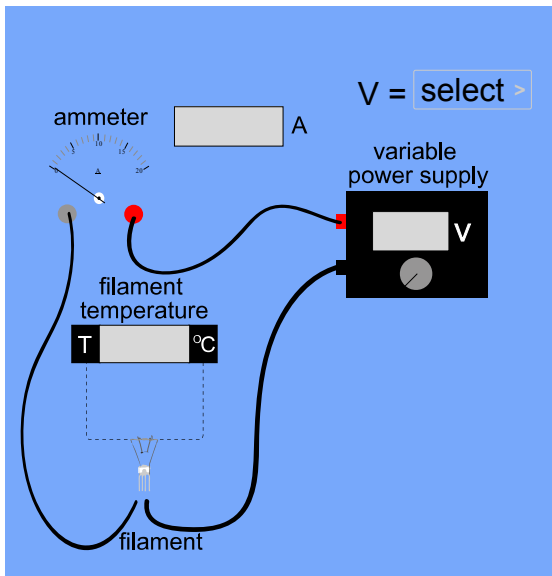
Explain why the current through the bulb could not be measured using the incorrect circuit.

This is because the ammeter is connected to the series before the current reaches the bulb. Hence, the current being recorded is actually the current from the power supply.

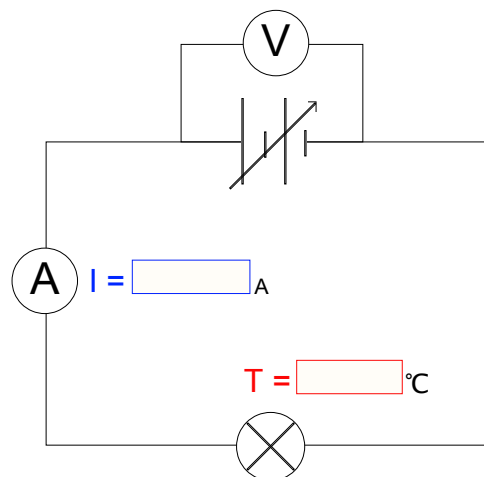
0/2

Question 6b (2 marks)

Student example



Circuit simulation



The student connects the components as shown and attaches a sensor to the filament. The sensor displays the temperature of the filament.

State the dependent and independent variables in this investigation.

Independent variable

Voltage, V

Dependent variable

Temperature

2/2

Question 6c (3 marks)

The student decides to measure the current at each of the following voltages. When asked about the reason for choosing these values the student says:

“I consider this to be a valid variation of voltage as it provides an appropriate number of measurements within the proposed range of voltage I am covering from 0 V to 12 V.”

Evaluate the values of voltage the student has chosen.

Voltage / V
0.0
0.4
0.8
1.2
3.6
4.0
9.2
11.6
12.0

The values chosen by the student is wrong because, I think it us always good to have a constant pattern on how the Independent variable is being changed, this is because it allows the student to pick out the pattern quicker and it will be easier to interpret the graph when analysing.

1/3

Question 7 (13 marks)

Question 7a (3 marks)

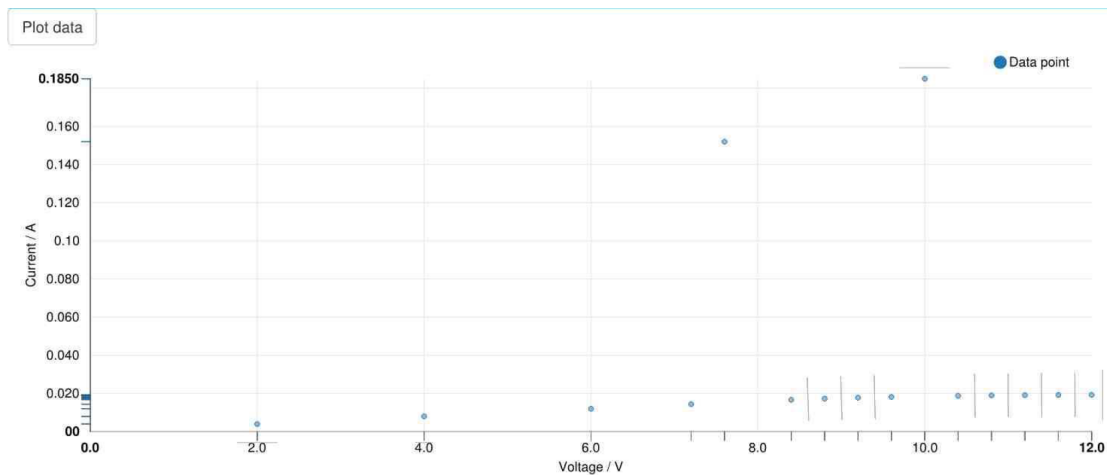
Choose your own appropriate values of voltage and use the simulation to **measure** the current. Also collect data about filament temperature and state any changes you observe in the lamp. When you finish completing the table, double click on **“Plot data”** below to produce the graph for your data and proceed to the next question.

Voltage / V	Current / A	Filament temperature / °C	Lamp observations
2.0	0.0040	540	no light
4.0	0.0080	1060	no light
6.0	0.0120	1580	no light
7.2	0.0144	1892	no light
7.6	0.152	1996	no light
8.4	0.0167	2110	no light
8.8	0.0173	2120	no light
9.2	0.0178	2130	no light
9.6	0.0182	2140	no light
10.0	0.185	2150	no light
10.4	0.0188	2160	little light
10.8	0.0190	2170	bit bigger light
11.2	0.0191	2180	light
11.6	0.0192	2190	bright light
12.0	0.0193	2200	very bright light

1/3

Question 7b (3 marks)

Using the graph, **describe** the relationship between voltage and current in the circuit.



When the voltage increases the current also increases.

1/3

Resistance (R) is defined as the ratio of voltage (V) across a material to the current (I) flowing through the material. The unit of resistance is the ohm and its symbol is Ω .

$$R = \frac{V}{I}$$

Question 7c (4 marks)

Describe how resistance changes in the filament across the range of the experiment. You should choose two points on the graph to calculate values of resistance to support your answer.

the resistance change through of the experiment. At the begining voltage 2.0 current 0.0040 the resistance was 500. At the end 12.0 voltage and 0.0193 current it was 621.76 this shows that there is a 121.76 resistance difference in the lowest and the highest reading.

4/4

Question 7d (3 marks)

Before starting the experiment, the following hypothesis was proposed:

"In all materials, the current is directly proportional to the voltage."

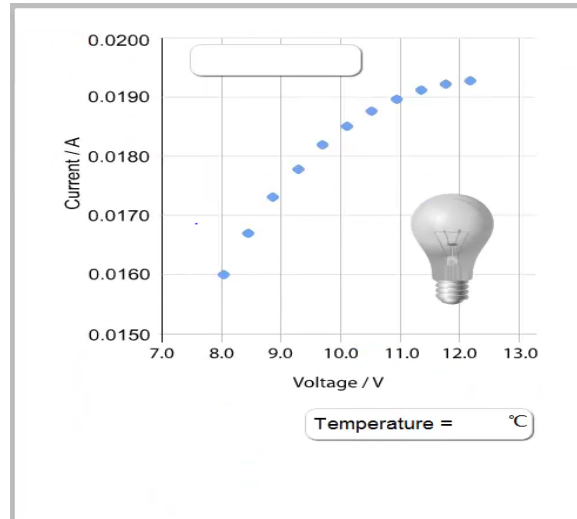
Discuss whether or not the results from this experiment support this hypothesis.

They do not because proportional means that they are equal and they are in a way so if he said when the voltage increases so does the current he would have been perfectly correct but now he has made one little mistake. It does support the results.

0/3 The answer is not clear enough for the award for any of the marking points.

Question 8 (10 marks)

A second student carries out a similar experiment using a different light bulb. He realizes that the lamp begins to glow above a certain temperature. Hover over the points on the graph to show the data values.



Question 8a (1 mark)

For these results, **state** the voltage at which the light bulb begins to glow.

10.4 Volts

1/1

Question 8b (2 marks)

All materials radiate energy in the form of electromagnetic waves. The frequency of the waves increases with temperature.

Explain, with reference to the electromagnetic spectrum, why the filament only glows above a certain temperature.

The temperature is really what makes the filament glow. The higher the temperature, the higher the kinetic speed of the particles so the brighter they will appear. It only glows above a certain temperature, because prior temperatures won't make the particles move fast enough that they will radiate their energy in form of electromagnetic waves. Actually, they will in fact radiate some electromagnetic waves but they will only be visually noticeable at certain temperatures. Once those 10.4 volts are reached, the lamp will glow.

1/2 Above certain temperature the EM waves are in the visible range.

Question 8c (5 marks)

Kinetic theory describes how particles in materials are in constant motion. **Interpret** the results of the experiment and use kinetic theory to **explain** the results.

The results I have previously explained too but I will repeat. The glowing in the filament is caused by the temperature which determines the kinetic energy of the particles in that material. This means that the higher temperature particles have, the more they will move. If they reach a certain temperature, they will move with such a great speed that they will be glowing, because if particles move with high speed they are obviously going to get hot. This is why when the 10.4 volts are reached, the kinetic energy in the particles is so high, that they will glow due to how much energy they have. This causes the filament to glow.

1/5

Question 8d (2 marks)

Outline another experiment that the student could perform to extend this investigation.

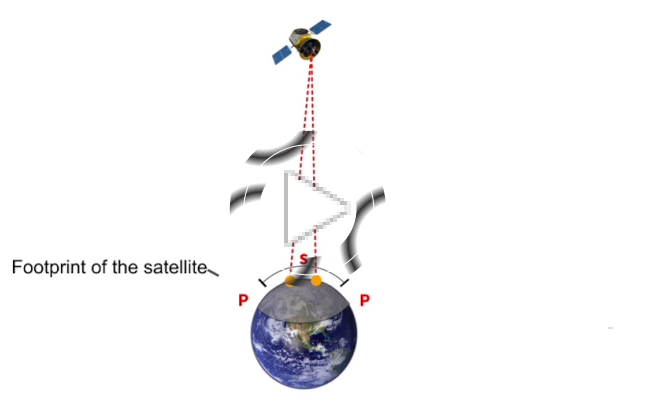
He could do an experiment, to see how the resistance in the filament will affect the temperature of the filament, in order to see if the resistance has an effect on the glow or temperature of the filament.

2/2

Question 9 (16 marks)

Communication in the modern world relies on transmission using satellites. Pictures, documents, videos and songs are examples of information that can be converted into electromagnetic waves. The electromagnetic waves are sent from a ground station to a satellite and then retransmitted to a second station on Earth. Satellite transmission means that the electromagnetic waves can be sent over much larger distances than are possible with ground transmission.

The animation shows a simple model of a satellite transmission where s is the ground distance between the two stations, h is the height of the satellite above the surface of the Earth and the P marks show the limits of the satellite footprint. Signals travel at the speed of light from the ground station to the satellite and back.



A study is performed to determine if there is a relationship between ground distance (s) and transmission time (t).

Question 9a (2 marks)

Identify the independent, dependent and control variables for this experiment.

transmission time t :

dependent

height h :

controlled

ground distance s :

2/2

independent

Question 9b (3 marks)

Formulate and **justify** a hypothesis about the relationship between the variables for this study.

When the ground distance increasing the transmission time increases, since the waves being transmitted will take a longer route to reach the satellite from the station on earth and back from the satellite to the other station.

2/3 They have linked dependent and independent. The link is correct. The final mark point is missing, incorrect explanation.

Question 9c (3 marks)

Describe the effect an unexpected change of the control variable would have on the **independent** and **dependent** variables.

Independent variable:

The altitude can alter the coverage area in which the stations are located in, so if the altitude of the satellite decreases then the area covered will decrease which will maybe cause the stations to be out of coverage and no waves will be transmitted.

Dependent variable:

The dependent variable (time) will decrease if the altitude of the satellite to earth decreased since the waves will take a shorter route and vice versa.

2/3

Question 9d (2 marks)

Use the animation to **outline** why there is a maximum possible ground distance between stations.

Because the the distance between the stations is dependable on the area that the satellite can cover.

0/2 not good enough

Question 9e (2 marks)

In the animation above, the value of s can be set to small values (even zero).

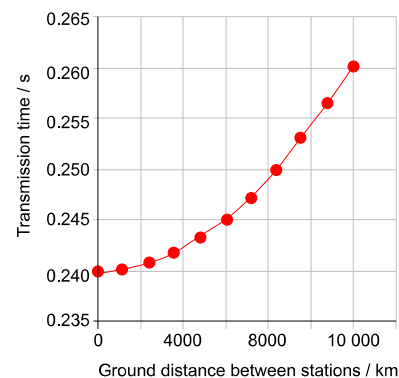
Explain why in a real situation, satellite transmission would not even be considered for small distances.

because if the station have a very small distance between them, then the waves can be directed from one station to the other directly , without the need for a satellite. however, satellites are utilized since you cant direct waves directly between stations that are far awa y from each other.

0/2

Question 9f (2 marks)

The graph shows data collected from the satellite animation. **Comment** on the shape of the graph.



the graph indicates a direct relationship since when the ground distance increases the transmission time increase.

0/2

Question 9g (2 marks)

Use your answer to part (f) to **select** the correct option. **Justify** your answer.

- The results support the hypothesis.
- The results do not support the hypothesis.

When the gorund distance increasing the transmission time increases, since the waves being transmitted will take a longer route to each the satellite from the station on earth and back from the satellite to the other station.

2/2

Question 10 (12 marks)

Satellites can be used to access the internet.

Discuss and **evaluate** the advantages and disadvantages of internet access using satellites compared to traditional cable-based internet access. In your answer you should include:

- an advantage of satellite internet access
- a disadvantage of satellite internet access
- technological considerations
- economic factors
- a concluding appraisal.

Satellites are a very efficient and new method to send signals when the target places are very far away. These could be used for internet access but it has its advantages with disadvantages compared to traditional cable based internet access.

Satellites are now the modern way of communicating to far locations on earth but they might not be the most useful for internet access. One reason for this is because sending a satellite to space is very expensive as well as running it, maintaining it and also creating the base locations which in this case would not have to be common and household object. Although it is very advanced technologically, it is very expensive to make and maintain considering its cost to build and maintain.

An advantage of satellites is that it is very advanced and allows information to be sent across the world at a very fast transmission time which traditional cable internet would be possible. By having satellite internet, it would make internet much faster as well as the share of information in time. This is useful in real life situations for example when information needs to be shared emergently like a natural disaster. In these situations, cable internet is not as effective as satellite information.

Although it is more expensive, could cause more pollution to make, maintain and space pollution as more satellites would be orbiting the earth, satellite internet could potentially be very useful in the future for emergency reasons. For household internet access, it is not necessary to have new technology that is faster than the one that is available now a days but for connecting major important businesses or governments that are geographically located far away, it could be very useful. Internet is the base of our communication so it only makes sense to use more satellites but to a certain extent and only when it is relevant and useful to do so.

5/12

This response falls within the 4-7 marking band.

The advantage is relevant and appropriate.

The disadvantage is relevant and appropriate.

The technological consideration is justified.

The economic factor is justified.

Question 11 (23 marks)

X-rays are a form of ionising radiation. Other forms of ionising radiation include alpha particles, beta particles and gamma rays.

Question 11a (3 marks)

Describe the process of ionisation by one of the forms of ionising radiation.

The ions are moving very quickly and they are able to pass through dense materials.

0/3

Question 11b (2 marks)

Outline the danger of ionising radiation for living cells.

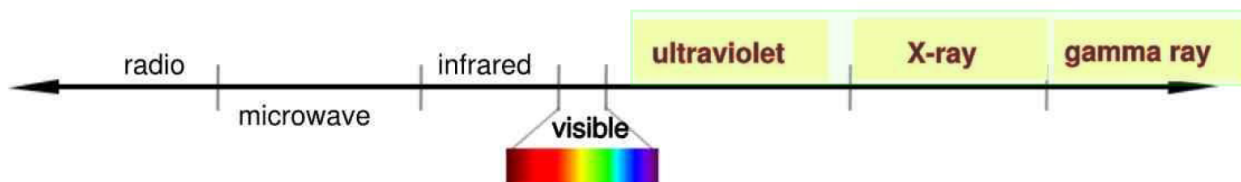
The danger for living cells is that ionising can affect them and change them, which can cause mutation.

1/2

Question 11c (1 mark)

X-rays, gamma rays and ultraviolet light are all forms of electromagnetic radiation.

Label the diagram of the electromagnetic spectrum.



1/1

Question 11d (3 marks)

X-rays and gamma rays can both be used by doctors to produce images of the internal structure of the human body. The different properties of X-rays and gamma rays produce different types of image. An X-ray image is formed by projecting X-rays, and then capturing the “shadow” on a surface that reacts to X-ray radiation.

Using information from the table, **discuss** why X-rays are used, rather than ultraviolet or gamma rays, when doctors wish to make images of a person’s bones.

	ultraviolet	X-rays	gamma rays
absorption by skin	high	low	low
absorption by bones	high	high	low
absorption by soft tissue	high	medium	low

This is because X-rays and gamma rays are the only rays of these three which can easily pass through the human skin. So why are X-rays used and not gamma rays, this is because X-rays get absorbed by bones, but gamma rays are passing right through the bones. So you would not see the bones when you are using gamma rays, but you can see them very clearly when the doctor is using X-rays.

3/3 Clear implication that UV does not pass through.

X-rays are not the only means of producing medical images. There are different options for producing medical images. Information about some of the options is presented in the tables below.

X-ray



Details of bony structures	High detail
Details of soft structures	No image possible
Ionising radiation exposure	Equivalent to 1/10 annual radiation dose from natural sources
Cost to patient per image	\$70
Time taken for scan	5 seconds
Is 3D imaging possible?	No
Other issues	None

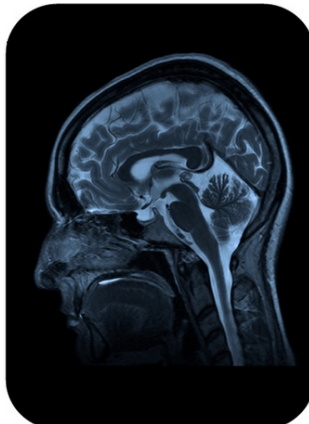
CT scan



Details of bony structures	High detail
Details of soft structures	Good detail
Ionising radiation exposure	10 times annual radiation dose from natural sources
Cost to patient per image	\$2000
Time taken for scan	30 seconds – 5 minutes
Is 3D imaging possible?	Yes
Other issues	<ul style="list-style-type: none"> • Very obese patients may not fit in the scanning machine or may be too heavy for the table • Can't scan image bone, soft tissue and blood vessels at the same time

© Aaron Fulkerson

MRI



Details of bony structures	Low detail
Details of soft structures	High detail
Ionising radiation exposure	None
Cost to patient per image	\$4000
Time taken for scan	15 minutes – 2 hours
Is 3D imaging possible?	Yes
Other issues	<ul style="list-style-type: none"> • Potential claustrophobia • Can't be used by patients with pacemakers or other metal implants

© iStockphoto.com/kalus

Ultrasound



Details of bony structures	Not used for bones
Details of soft structures	Good detail
Ionising radiation exposure	None
Cost to patient per image	\$500
Time taken for scan	10 – 15 minutes
Is 3D imaging possible?	Yes
Other issues	Requires highly trained operator

© Kenneth C. Zirkel

Question 11e (14 marks)

All hospitals have a limited amount of money to spend on medical equipment. Hospital managers have to balance the advantages and disadvantages of different types of equipment when they decide how to spend their money.

Using the information in the tables, **discuss** and **evaluate** the medical imaging equipment **you** would recommend to the hospital manager, clearly justifying your recommendation. In this extended piece of writing, you should consider the social and economic factors and include:

- the advantages of your chosen equipment
- the disadvantages of your chosen equipment
- the perspective of the hospital
- the perspective of the patients.

So if a hospital is able to get the equipment for two than they would have everything they need. But if a hospital is just able to organize one than they should take the x-ray equipment. The advantage is that the price to get it cheap and to use it is quick, so they can scan patient after patient. The disadvantage is that 3D imaging is not possible and x-rays have a chance to change the human cell, if you have a overdosis of it. The perspective of the hospital is that they can scan patient after patient, so they can make money. The perspective of the patient is that they don't have to pay to much money and they get the image very quickly. So a x-ray equipment is perfect for the patient, the only thing is that the patient should not come to often for a x-ray scan. This is like I already wrote, because the x-rays can change the human cells and cause mutations.

5/14 The answer given here fulfils all the requirements of the 3-5 band: there is an advantage, but it is not justified; there is a disadvantage, but again not justified. Information from the table is used and there is a comment about the hospital.

Question 12 (3 marks)

Look at the two very different images of feet.

Image 1



© International Baccalaureate Organization 2016

Image 2



© GUSTOIMAGES/SCIENCE PHOTO LIBRARY

The second image is by the artist Hugh Turvey who uses X-rays in his work. This piece of art is called *Femme Fatale* and shows the foot of a woman wearing a high-heeled shoe. The artist has used an X-ray, normally used in science, medicine or industry to create this artistic image.

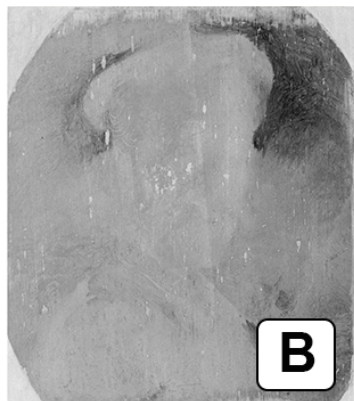
Outline what the use of science can reveal that a photograph does not. Refer to the image and apply the ideas that you have been introduced to in this task in your answer.

The use of x-ray can show the bone structures of someone, while photography does not, and that is clearly shown in both images.

Question 13 (4 marks)



A



B



C

Compare image C to images A and B.

© <http://www.rembrandt.us.ac.be/>

Some art historians suggest that Rembrandt reused the canvas shown in image B.

Question 13a (2 marks)

Outline the evidence in these three images that supports the suggestion that the canvas was reused.

-the canvas was reused by the artist as he applied the XRF method to examine his painting from another way which indicates creativity, since he wanted to observe his own image in a different way.

0/2 not good enough

Question 13b (2 marks)

Suggest two benefits of using XRF to examine paintings rather than removing areas of paint.

-the hidden information of a specific painting can be revealed.

1/2

Question 1 (5 marks)

The following table contains information that can be used to describe mass or weight.

Question 1a (2 marks)

Select the correct option to complete the table.

	Mass	Weight
Units	kilogram	independent of gravitational field strength
Type of quantity	size only	size and direction
Effect of gravitational field strength	newton	dependent on gravitational field strength

0/2 Only one row is correctly completed but for the minimum one mark there has to be at least two rows correct therefore no mark is awarded.

Question 1b (2 marks)

The table below contains information about four planets in the solar system. Using this information, **select** the **three** unnamed planets and complete the table.

	Relative mass compared to Earth	Orbital period/ Year	Number of moons	Main gases in atmosphere	Are there any rings present?
Earth	1	1	1	N ₂ , O ₂ , Ar	No
Venus	0.82	0.62	0	CO ₂ , N ₂	No
Neptune	17.2	164.8	14	H ₂ , He	Yes
Jupiter	317.8	11.86	67	H ₂ , He	Yes

1/2 One planet is in the correct position and this gives one mark.

Question 1c (1 mark)

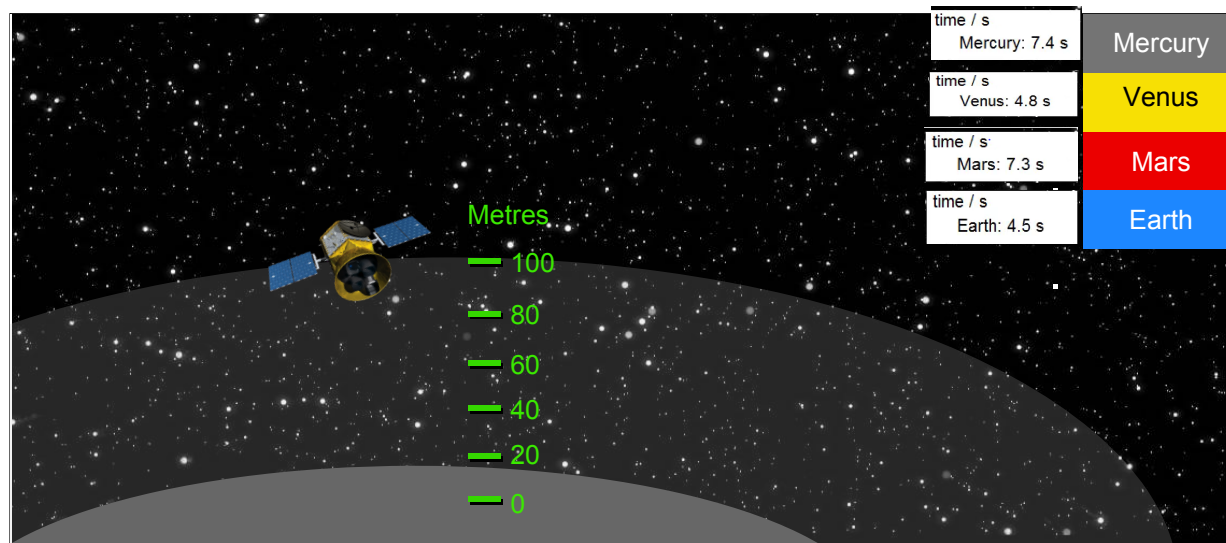
State why the outer planets tend to be colder than the inner planets.

outer planets are colder than the inner planets because of the sun. planets like mercury venus earth mars are hotter because the sun is near to them. As we go to the outer like jupiter saturn uranus and neptune are far from the sun that's why they are colder

1/1 Correctly identifies that the outer planets are farther than the sun and therefore cooler.

Question 2 (11 marks)

A robotic probe is sent into space to collect data from three of the four inner planets: Mercury, Mars and Venus. While passing close by each planet the probe drops a test object from a height of 100.0 m, the shape of the object ensures that any frictional forces are negligible over a fall of this distance.



Question 2a (3 marks)

Using the data you collected above, **calculate** the acceleration due to gravity on Mercury and Mars.

Mercury:

$$100 = (1/2)(g)(7.4)^2$$

$$100 = 27.38g$$

$$g = 3.65 \text{ms}^{-2}$$

Mars:

$$100 = (1/2)(g)(7.3)^2$$

$$100 = 26.65g$$

$$g = 3.75 \text{ms}^{-2}$$

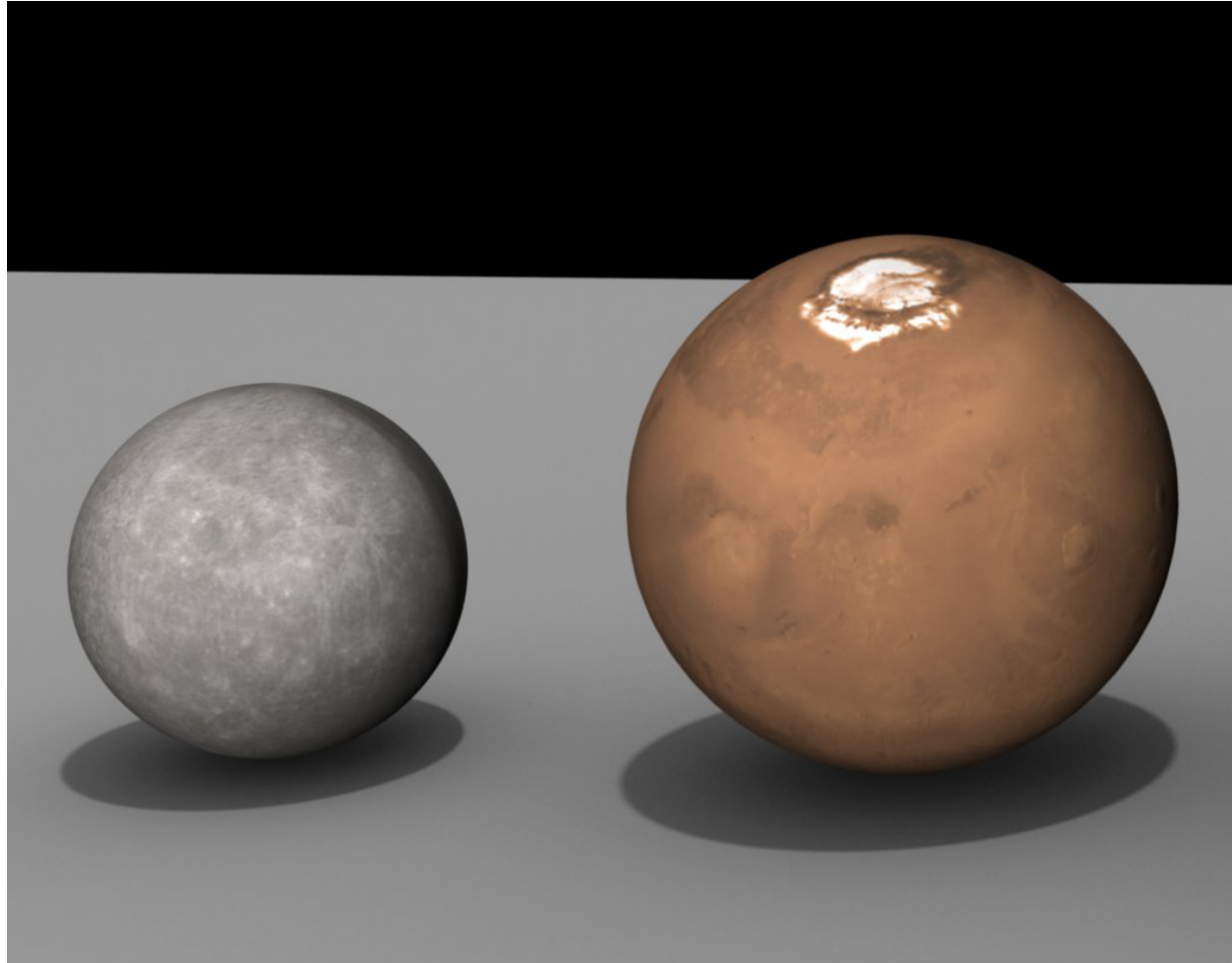
2/3 The final answers are not given to the correct significant figures and therefore the final mark is only 2.

The scientists receiving the data on Earth know that gravitational field strength (g) is proportional to a planet's density (ρ) and its radius (r).

gravitational field strength \sim density \times radius

$$g \sim \rho \times r$$

The radius of Mercury is about two thirds of the radius of Mars.



Mercury

Mars

Question 2b (2 marks)

Explain why Mars and Mercury can have almost the same value of g , if Mars has a much larger radius.

This is because Mars is denser than mercury. Considering the formula of gravitational field strength, density is directly proportional to gravitational field strength which means although mars is smaller than mercury, it will have a greater gravitational field strength due to its larger density.

0/2 Mars has a density less than Mercury therefore the constant reference to Mars having a higher density (and Mars being smaller) means the overall answer is incorrect.

Next, the space probe visits two of Jupiter's moons: Io and Ganymede.

The experiment is repeated and again a test object is dropped from a height of 100.0 m.

The gravitational field strength of Io = 1.8 N kg^{-1} .

The gravitational field strength of Ganymede = 1.4 N kg^{-1} .

The test object has a mass of 20 kg.

Question 2c (3 marks)

Use information from the formula sheet to **calculate** the gravitational potential energy (E_p) of the test object before it is dropped over Io.

$$E_p = 20(100)(1.8)$$

$$E_p = 3600 \text{ J}$$

3/3 The equation is clearly shown from the values used to calculate the final answer.

All of the test object's gravitational potential energy (E_p) transforms to kinetic energy before hitting the surface of the moons.

Question 2d (3 marks)

The test object travels faster before hitting the surface of Io than it does before hitting the surface of Ganymede. **Explain** this observation.

This is due to the greater acceleration in Io than in Ganymede. The object accelerates to a greater speed before hitting the surface of Io than it does before hitting the surface of Ganymede due to a greater value of acceleration in Io. The maximum velocity reached, also known as the terminal velocity in Io is greater than the terminal velocity in Ganymede due to greater gravitational field strength. As a result it appears to be travelling faster in Io than in Ganymede.

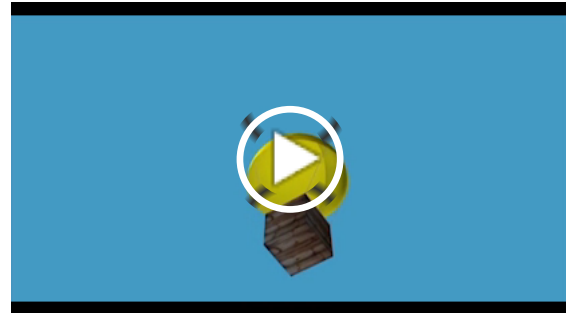
1/3 Correct comment made that GPE on Io is greater than Ganymede. The rest of the answer is basically repeating the information given in the question.

Question 3 (11 marks)

When the space probe in Question 2 is investigating acceleration, air resistance is negligible.

On Earth, a parachute can be used to increase air resistance.

The maximum speed a falling object reaches is known as the terminal velocity.



Question 3a (2 marks)

Some students perform an investigation into the terminal velocity of a simple parachute. One of the students wants to investigate how the area of the parachute affects its terminal velocity.

Suggest one piece of equipment that the student will need to perform this experiment.

Equipment: Stop watch, ruler

Stop watch is to record the time taken for the parachute to reach the ground. Ruler is to measure the distance that the parachute wa release.

2/2 The stop watch is correct (ruler is extra but the stopwatch is used for the mark).

Question 3b (3 marks)

Suggest and explain a hypothesis for this experiment.

The larger the surface area of the parachute, the more time the object will take to land on the ground.

2/3 There is no mention of increasing air resistance.

Question 3c (3 marks)

State one variable that the student will need to control. **Describe** how this variable should be controlled and why it should be controlled.

Variable

The mass of the object

How the variable should be controlled

Use object that contain the same mass for each experiment.

Why the variable should be controlled

If we use diffrent mass for each experiment the result will be diffrent.

2/3 No mention of why the mass will affect the results i.e. the downward force would increase.

Question 3d (3 marks)

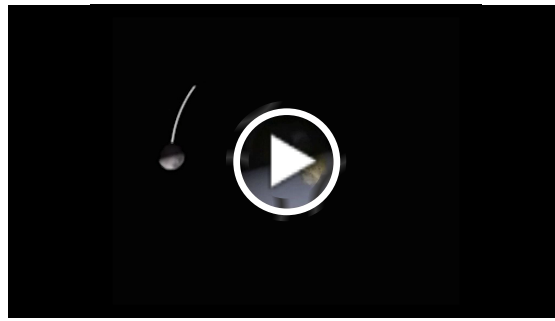
Explain what results the student will need to collect to ensure that they have sufficient relevant data.

The time taken for the parachute to reach the ground and the distance they drop the parachute.

0/3 There is no explanation of the range of the readings or the repeats needs.

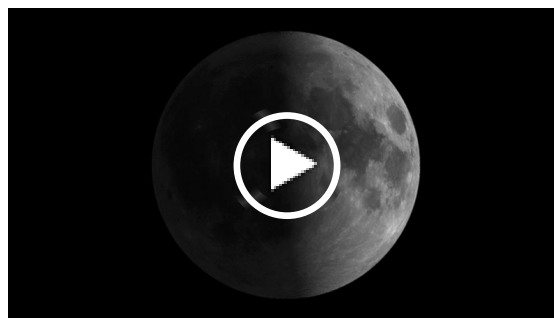
Question 4 (3 marks)

The first animation shows the Moon orbiting the Earth.



www.en.wikipedia.org/wiki/Lunar_phase

The second animation shows how the Moon looks each day, when viewed from the Earth over a complete month.



www.en.wikipedia.org/wiki/Libration

Question 4a (2 marks)

Using the information from both animations, **describe** why the appearance of the Moon changes over a month.

As the moon moves around the Earth and the Earth moves around the sun, the moon is visible when it's in between the sun and the Earth. But as it rotates the moon will become less and less visible. It's would see the edge of the moon, then half of the moon won't be seem and then another quearter of the moon won't be seem. As the moon rotates already half of the Earth, human won't be able to see the moon anymore until it rotates back it one quarter will appear and after half of the moon until it back to the original place wher e it shows the whole moon.

1/2 The moon is not visible when it is between the sun and the Earth as this is when the Earth only sees the 'back' of the sun facing away from the sun and thus in shadow.

Question 4b (1 mark)

The Moon affects the tides on Earth. **Identify** the force that produces this effect.

The force that produces this effect is gravity force

1/1

Question 5 (2 marks)

In the 1950s, cosmologists proposed the "steady-state" theory to explain certain aspects of the universe after it was observed to be expanding. This theory states that:

- the universe has no beginning or end
- the temperature of the universe has always been constant and will not change in the future
- as the universe expands, new matter is created and the density of the universe remains constant.

Outline two ways in which this theory is different to the "big-bang" theory.

- 1) The universe is caused by a big bang / collision, hence resulting in a start.
- 2) As the universe expands, the density of the universe will increase.

2/2 The density of the universe is not constant and there is a moment of beginning.

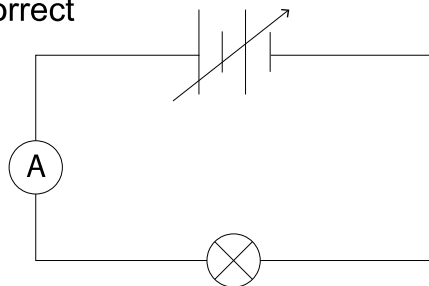
Question 6 (7 marks)

A student investigates an electrical circuit containing a variable power supply, an ammeter and a filament lamp (bulb) in which the current through the bulb can be changed.

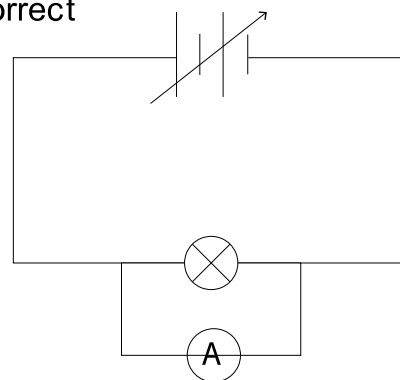
One of the circuit diagrams below is incorrect, the other circuit diagram is correct.

Question 6a (2 marks)

Correct



Incorrect



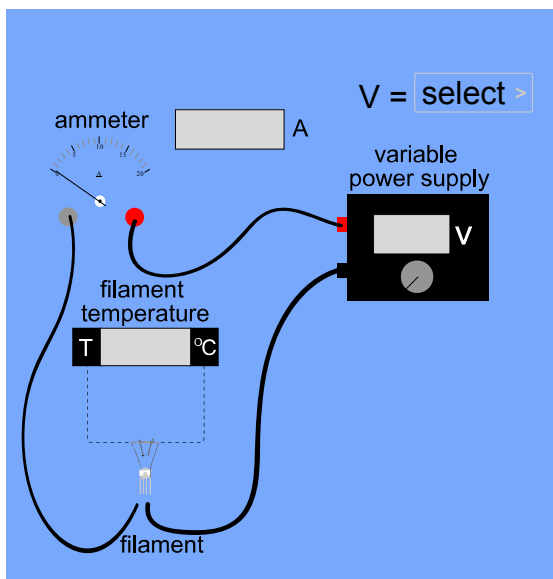
Explain why the current through the bulb could not be measured using the incorrect circuit.

Because in the incorrect circuit the current is being split between the ammeter and the lightbulb. For it to work the ammeter must be measuring all of the current.

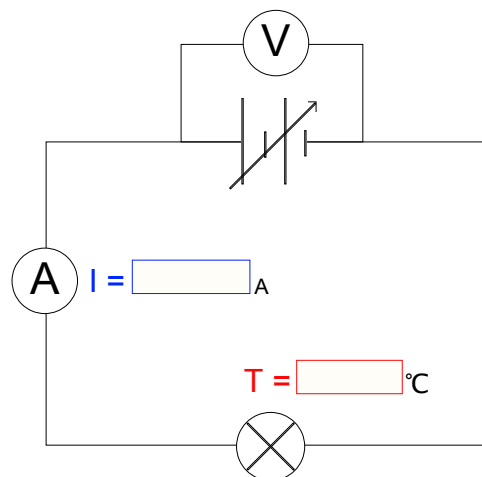
1/2 As the ammeter has low resistance, all of the current should flow through it when it is in series with the bulb.

Question 6b (2 marks)

Student example



Circuit simulation



The student connects the components as shown and attaches a sensor to the filament. The sensor displays the temperature of the filament.

State the dependent and independent variables in this investigation.

Independent variable

Amps

Dependent variable

temperature of filament

1/2

Question 6c (3 marks)

The student decides to measure the current at each of the following voltages. When asked about the reason for choosing these values the student says:

“I consider this to be a valid variation of voltage as it provides an appropriate number of measurements within the proposed range of voltage I am covering from 0 V to 12 V.”

Evaluate the values of voltage the student has chosen.

Voltage / V
0.0
0.4
0.8
1.2
3.6
4.0
9.2
11.6
12.0

The student has chosen an appropriate amount of measurements within the range but has not chosen enough varied values. He has over a 5 V range where he does not measure any values. Instead he should choose evenly spaced values to ensure enough variety.

3/3 The candidate has identified that there are enough (9) measurements and that they cover the range (0 to 12 V).

Question 7 (13 marks)

Question 7a (3 marks)

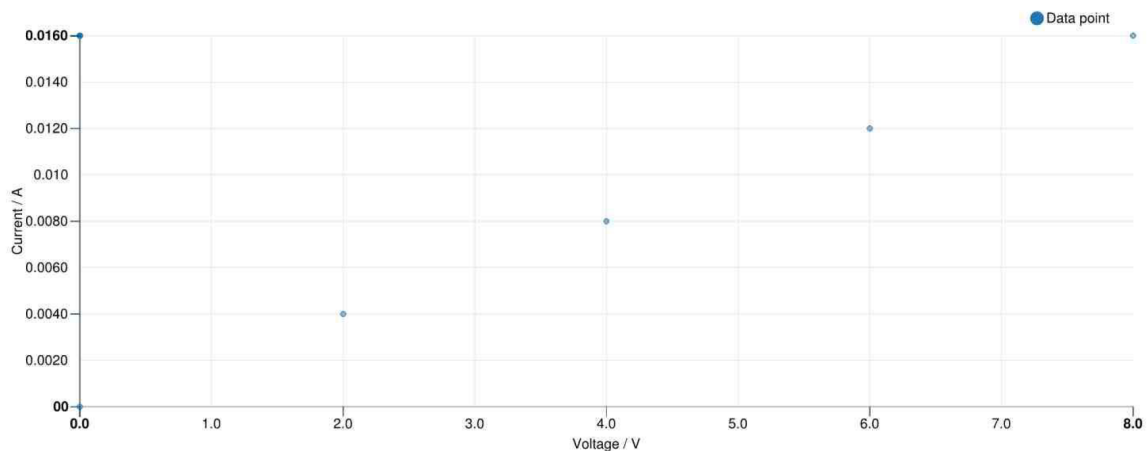
Choose your own appropriate values of voltage and use the simulation to **measure** the current. Also collect data about filament temperature and state any changes you observe in the lamp. When you finish completing the table, double click on **“Plot data”** below to produce the graph for your data and proceed to the next question.

Voltage / V	Current / A	Filament temperature / °C	Lamp observations
0.0	0	20	No light
2.0	0.0040	540	No Light/ Dull
4.0	0.0080	1060	Dull
6.0	0.0120	1580	Dull
8.0	0.0160	2100	Dull

1/3 Two different descriptions used for the same result.

Question 7b (3 marks)

Using the graph, **describe** the relationship between voltage and current in the circuit.



As the voltage increases, the current in the circuit also increases.

1/3

Resistance (R) is defined as the ratio of voltage (V) across a material to the current (I) flowing through the material. The unit of resistance is the ohm and its symbol is Ω .

$$R = \frac{V}{I}$$

Question 7c (4 marks)

Describe how resistance changes in the filament across the range of the experiment. You should choose two points on the graph to calculate values of resistance to support your answer.

Based on Ohm's Law, resistance should be constant, as voltage increases, and current also increases, provided there is no change in temperature.

For example,

Note: R = Resistance

$$R_1 = 2.0 \div 0.0040 = 500\Omega$$

$$R_2 = 4.0 \div 0.0080 = 500\Omega$$

Hence, Resistance remains constant.

4/4 The two resistances have been compared, this fulfils the marking points of commenting on the two values.

Question 7d (3 marks)

Before starting the experiment, the following hypothesis was proposed:

"In all materials, the current is directly proportional to the voltage."

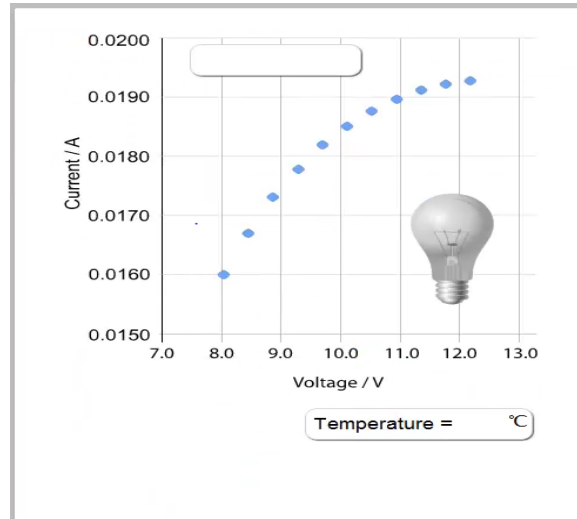
Discuss whether or not the results from this experiment support this hypothesis.

The results from this experiment support this hypothesis, because it shows as the voltage increases, the current also increases. Besides that, it passes through the origin. Furthermore, it shows a positive gradient.

1/3

Question 8 (10 marks)

A second student carries out a similar experiment using a different light bulb. He realizes that the lamp begins to glow above a certain temperature. Hover over the points on the graph to show the data values.



Question 8a (1 mark)

For these results, **state** the voltage at which the light bulb begins to glow.

voltage= 10.4 V. 1/1

Question 8b (2 marks)

All materials radiate energy in the form of electromagnetic waves. The frequency of the waves increases with temperature.

Explain, with reference to the electromagnetic spectrum, why the filament only glows above a certain temperature.

The filament only glows above a certain temperature because the filament requires a certain amount of energy in order to glow. The spectrum relates to the frequency of the electromagnetic waves, so when they have a high enough frequency meaning that the temperature is high enough, to create light. Also, the particles when exposed to temperature move fast enough to radiate heat.

1/2

No mention of the EM spectrum only being visible at certain frequencies.

"to create light": this is a confusing statement they emit the visible spectrum is correct rather than 'create' light.

Question 8c (5 marks)

Kinetic theory describes how particles in materials are in constant motion. **Interpret** the results of the experiment and use kinetic theory to **explain** the results.

In the experiment we can see that as the temperature increases while the voltage and current do too, the curve in the graph becomes less and less steep, and eventually it will reach a constant value.

This can be related to the kinetic theory, where particles are being heated up due to the energy created by increasing the voltage and current, that they will eventually reach a state where they can't vibrate any faster, so that is when the bulb will be lit at its maximum. Also, the motion of particles is increasing as the temperature increases, so the higher the voltage and current, the faster the particles will be moving and the more the light bulb will shine. The motion of particles increasing is key to the bulb being lit.

2/5 Fails to link the particle vibration to an increasing resistance due to collisions in the material and this causes the plateau in the graph.

Question 8d (2 marks)

Outline another experiment that the student could perform to extend this investigation.

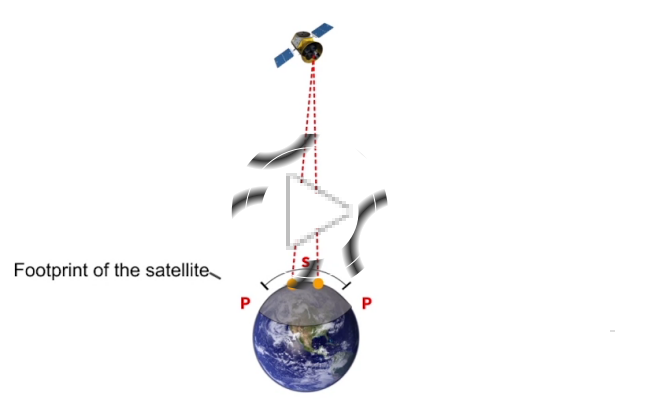
To extend this investigation, the student could do an investigation on different types of light bulbs, and how they would react to the increase in temperature, or in motion of particles. Will they also light up? Will the temperature also increase by 10⁹ C ?

2/2 Clearly gives another experiment and there is justification.

Question 9 (16 marks)

Communication in the modern world relies on transmission using satellites. Pictures, documents, videos and songs are examples of information that can be converted into electromagnetic waves. The electromagnetic waves are sent from a ground station to a satellite and then retransmitted to a second station on Earth. Satellite transmission means that the electromagnetic waves can be sent over much larger distances than are possible with ground transmission.

The animation shows a simple model of a satellite transmission where s is the ground distance between the two stations, h is the height of the satellite above the surface of the Earth and the P marks show the limits of the satellite footprint. Signals travel at the speed of light from the ground station to the satellite and back.



A study is performed to determine if there is a relationship between ground distance (s) and transmission time (t).

Question 9a (2 marks)

Identify the independent, dependent and control variables for this experiment.

transmission time t :

dependent

height h :

control

ground distance s :

2/2

independent

Question 9b (3 marks)

Formulate and **justify** a hypothesis about the relationship between the variables for this study.

Hypothesis: Height is fixed, its always 35800 km from the Earth to satellite, so it is a control variable. Independent is the variable which we change and in this experiment we change distance and after its affect the transmission time changes (dependent). As the distance increases the path of waves increase too and transmission time increase too. According to the formula of time=distance/speed, speed is constant, speed of light, but distance changes.

Question 9c (3 marks)

Describe the effect an unexpected change of the control variable would have on the **independent** and **dependent** variables.

Independent variable:

If the control becomes shorter, the distance in which satellite could transmit waves become smaller, the area or path in which satellite can transmit becomes fewer. If it rises more distance satellite can transmit

Dependent variable:

If the control variable will be bigger, waves might not reach satellite, nothing will appear, or if it will reach the transmission time will be longer. If the control will become shorter, transmission time will decrease too

2/3 The effect on independent variable or ground distance would be unaffected, this is not clear from the answer given.

Question 9d (2 marks)

Use the animation to **outline** why there is a maximum possible ground distance between stations.

It's called a footprint of satellite. One satellite can't transmit waves on whole surface, that's why it takes a not big part of the Earth. If the maximum distance will increase, station will catch signals very hard, because the angle of accepting will be huge and it required a strong acceptor.

1/2 The answer is not very clear. It appears that the candidate has understood that the station is not in the footprint of the satellite, but this is not very clear.

Question 9e (2 marks)

In the animation above, the value of s can be set to small values (even zero).

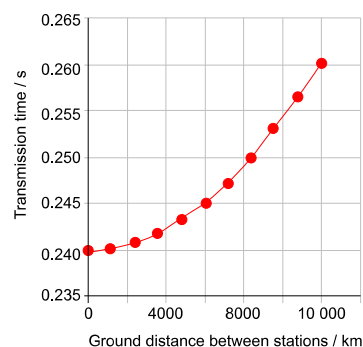
Explain why in a real situation, satellite transmission would not even be considered for small distances.

because there is a network connection in the not big area. for example to use satellite only in China is not required, because they can use internet. But if it required to transmit information between ocean, network won't help, that's satellite required for the connection between far distances. And internet is cheaper than to make and hold satellite

1/2 No mention of time increasing if the satellite is used for short distances.

Question 9f (2 marks)

The graph shows data collected from the satellite animation. **Comment** on the shape of the graph.



This graph has a parabola form. It's not a linear function. as the distance increases transmission time increases too, but it's the rise is not equal it's like an acceleration.

1/2 Understanding that the time increases but this could be exponential but not a parabola

Question 9g (2 marks)

Use your answer to part (f) to **select** the correct option. **Justify** your answer.

- The results support the hypothesis.
- The results do not support the hypothesis.

as I said in the hypothesis as the distance increases the time of transmission increases too. The trajectory of waves from station to satellite to station can be explained as the isosceles triangle. When the base (distance) increases, two equal sides become longer too, because their origin to satellite becomes further.

Question 10 (12 marks)

Satellites can be used to access the internet.

Discuss and **evaluate** the advantages and disadvantages of internet access using satellites compared to traditional cable-based internet access. In your answer you should include:

- an advantage of satellite internet access
- a disadvantage of satellite internet access
- technological considerations
- economic factors
- a concluding appraisal.

Satellites allow people to access any part of the internet from anywhere in the world. The information that someone puts onto the internet in California can be accessed by someone in South Africa in seconds. If the internet was only supported by cable-based access, it could become segregated to only sections of the world instead of being the interconnected and international platform that it is today. Anybody can access information from anywhere in the world that was uploaded from anywhere in the world, which is an important part of our global community and allows us to gain an understanding of different cultures that we would not otherwise be exposed to.

This interconnectedness and the vast extent of the internet has also allowed activities that have negative impacts on society or are illegal in many countries to grow and thrive on a global scale.

However, satellites can be expensive to build and maintain and need to be repaired periodically to ensure that they are and will continue to work properly. If there is debris that is also in orbit, the debris could damage satellites and cause massive land areas to be without the service that it provides for a long period of time while the satellite that was damaged is being repaired.

Personally, I think that using satellites for internet access is a good thing and will help move society forward at a faster pace, as we are becoming more international and have the ability to share and express ourselves and our opinions, feelings, ideas, etc online with the world. This helps us to be a more global community that has a better understanding of each other and our cultures and makes us more open minded.

5/12 The advantage is that internet connection is fast and connects global communities faster. Disadvantage is that satellites can be damaged by debris in space and this stops coverage for a long time. Economic factors are expensive to build and maintain. This answer is assessed in band 4-7.

Question 11 (23 marks)

X-rays are a form of ionising radiation. Other forms of ionising radiation include alpha particles, beta particles and gamma rays.

Question 11a (3 marks)

Describe the process of ionisation by one of the forms of ionising radiation.

Ionising radiation occurs when the nucleus of an atom become unstable, which than releases radiation in the form of alpha particles, beta particles and gamma rays. All of these particles have a different charge, however gamma is the main ray that is released.

0/3

Question 11b (2 marks)

Outline the danger of ionising radiation for living cells.

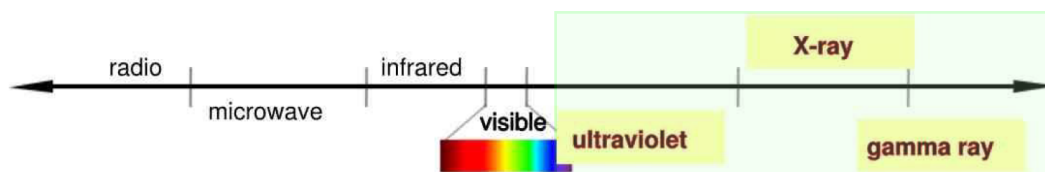
Radiation is a danger for living body cells as it kills cells, which contain extremely important information such as DNA for humans and animals. A body exposed to ionised radiation could eventually kill all body cells, which could eventually result to extreme health problems or possible death.

1/2

Question 11c (1 mark)

X-rays, gamma rays and ultraviolet light are all forms of electromagnetic radiation.

Label the diagram of the electromagnetic spectrum.



1/1

Question 11d (3 marks)

X-rays and gamma rays can both be used by doctors to produce images of the internal structure of the human body. The different properties of X-rays and gamma rays produce different types of image. An X-ray image is formed by projecting X-rays, and then capturing the “shadow” on a surface that reacts to X-ray radiation.

Using information from the table, **discuss** why X-rays are used, rather than ultraviolet or gamma rays, when doctors wish to make images of a person’s bones.

	ultraviolet	X-rays	gamma rays
absorption by skin	high	low	low
absorption by bones	high	high	low
absorption by soft tissue	high	medium	low

X rays are the most effective to use because they have they contain a high absorbtion of the bones, which allows doctors to see the bones clearly, while not causing a lot of damage to the skin and tissues of the body. This makes x rays extremely effective, and unlike other rays they are used because they cause the least harm to the persons body, and are the most safe.

X-rays are not the only means of producing medical images. There are different options for producing medical images. Information about some of the options is presented in the tables below.

X-ray

CT scan



Details of bony structures	High detail
Details of soft structures	No image possible
Ionising radiation exposure	Equivalent to 1/10 annual radiation dose from natural sources
Cost to patient per image	\$70
Time taken for scan	5 seconds
Is 3D imaging possible?	No
Other issues	None

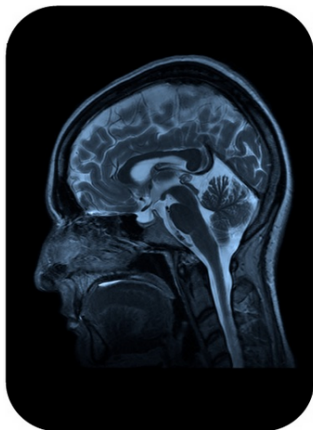


Details of bony structures	High detail
Details of soft structures	Good detail
Ionising radiation exposure	10 times annual radiation dose from natural sources
Cost to patient per image	\$2000
Time taken for scan	30 seconds – 5 minutes
Is 3D imaging possible?	Yes
Other issues	<ul style="list-style-type: none"> • Very obese patients may not fit in the scanning machine or may be too heavy for the table • Can't scan image bone, soft tissue and blood vessels at the same time

Aaron Fulkerson

MRI

Ultrasound



Details of bony structures	Low detail
Details of soft structures	High detail
Ionising radiation exposure	None
Cost to patient per image	\$4000
Time taken for scan	15 minutes – 2 hours
Is 3D imaging possible?	Yes
Other issues	<ul style="list-style-type: none"> • Potential claustrophobia • Can't be used by patients with pacemakers or other metal implants



Details of bony structures	Not used for bones
Details of soft structures	Good detail
Ionising radiation exposure	None
Cost to patient per image	\$500
Time taken for scan	10 – 15 minutes
Is 3D imaging possible?	Yes
Other issues	Requires highly trained operator

iStockphoto.com/kalus

Kenneth C. Zirkel

Question 11e (14 marks)

All hospitals have a limited amount of money to spend on medical equipment. Hospital managers have to balance the advantages and disadvantages of different types of equipment when they decide how to spend their money.

Using the information in the tables, **discuss** and **evaluate** the medical imaging equipment **you** would recommend to the hospital manager, clearly justifying your recommendation. In this extended piece of writing, you should consider the social and economic factors and include:

- the advantages of your chosen equipment
- the disadvantages of your chosen equipment
- the perspective of the hospital
- the perspective of the patients.

As a hospital manager, I would recommend the CT scanning technique. The main advantage of this equipment is the fact that it is extremely efficient for scanning; it can display both the bones and soft structures in good detail, so the doctors can use this machine for a range of medical cases, at different dimensions as the 3D option is also possible. Additionally, it is one of the equipments that takes the fastest to scan, which allows for a wide coverage of patients at a daily basis.

However, the main disadvantage of this product is the fact that it emits very high amount of radiation, which may be a severe harm to the patient. However, the most important aspect is accurate treatment, and if a patient uses this machine for treatment very rarely, it will not cause enough damage to his body in general. The scanner does have a couple of issues, as it cannot fit obese people and it cannot scan multiple sections at the same time, however these can be fixed by performing the scan test multiple times for example.

In terms of the perspective, the patients would view this as not a very pleasant idea, due to the high cost of the scan and the high risk of radiation. In terms of the hospital, the machine unfortunately does pollute high amounts of radiation, which emits fossil fuels, which could cause the hospital popularity to decrease due to the use of dangerous and polluting machinery, which most patients could be against of using.

12/14 The response falls into the 10-14 band, meets the requirements for advantage and disadvantage, a comment related to the patient but not to the hospital and no concluding statement.

Question 12 (3 marks)

Look at the two very different images of feet.

Image 1



© International Baccalaureate Organization 2018

Image 2



© CUSTOMIMAGES-SCIENCE PHOTO LIBRARY

The second image is by the artist Hugh Turvey who uses X-rays in his work. This piece of art is called *Femme Fatale* and shows the foot of a woman wearing a high-heeled shoe. The artist has used an X-ray, normally used in science, medicine or industry to create this artistic image.

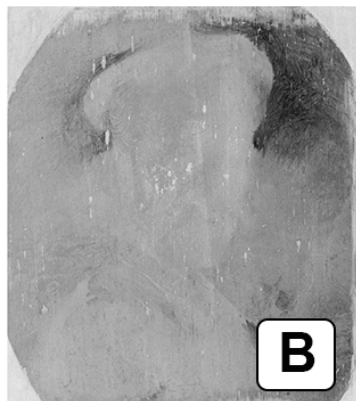
Outline what the use of science can reveal that a photograph does not. Refer to the image and apply the ideas that you have been introduced to in this task in your answer.

The use of science can show what is happening inside the body and a photograph can not. In the art piece it is evident that you can see the structure of the bone and how it looks. Also, science can reveal structures and the pressure being put on the foot as shown in the art piece.

Question 13 (4 marks)



A



B



C

© <http://www.rembrandt.us.ac.be/>

Compare **image C** to **images A** and **B**.

Some art historians suggest that Rembrandt reused the canvas shown in **image B**.

Question 13a (2 marks)

Outline the evidence in these three images that supports the suggestion that the canvas was reused.

The proof that the artist used the same canvas in B to draw C can be shown through the outline produced by the image B. Although it is an X-ray of image A, the outline of image B is extremely similar to that of the original piece C.

1/2

Question 13b (2 marks)

Suggest two benefits of using XRFs to examine paintings rather than removing areas of paint.

Using XRFs, not only allows historians to discover the type of paint or techniques the historians used, but it also allows them to investigate secrets lying beneath the surface of the painting. This helps them in further investigating the reason behind such art pieces and the general style of the artist, as he might've used such techniques in multiples of his artwork.

1/2