Ascham School

Trial Examination 2013

Physics

Time allowed: 3 hours (plus 5 minutes reading time)

Section 1

PART A 20 one mark multiple choice questions.

Write your answers in pencil on the Part A answer sheet. (20 marks)

Write your Candidate number on the Part A answer sheet.

PART B Short response questions.

Write your answers in the space provided. (60 marks)

Write your Candidate number at the beginning of Part B

Section 2

Option: Medical physics (25 marks)

Write your answers to this section in the writing booklet.

Write your Candidate number on each booklet you use.

A Periodic Table, A Data sheet and a Formula sheet are provided.

1. A satellite of mass M has an orbital period of 24 hours at an altitude of R. The orbital period of another satellite of mass 2M at an altitude of 3R is closest to:

A) 48 hours

B) 12 hours

C) 24 hours

D) 68 hours

2. The motor effect occurs when:

A) A current carrying conductor experiences a force in a magnetic field

B) A motor is briefly prevented from spinning

C) A stationary charge experiences a force in a magnetic field

D) The effect of a current carrying conductor on a magnetic field causes attraction between the conductor and field.

3. The aim of the Michelson Morley experiment was to:

A) Prove the existence of the aether.

B) Measure the speed of the Earth relative to the aether.

C) Determine the interference pattern between two lasers.

D) establish a null result.

4. Given that the range of wavelengths for UV light is between 400nm and 10nm, then the maximum energy of a photon of UV light is closest to:

A) 1.98×10^{-17} J

B) 4.97×10^{-19} J

C) 3.00×10^{8} J

D) 6.63×10^{-34} Js

5. Heinrich Hertz is best remembered for:

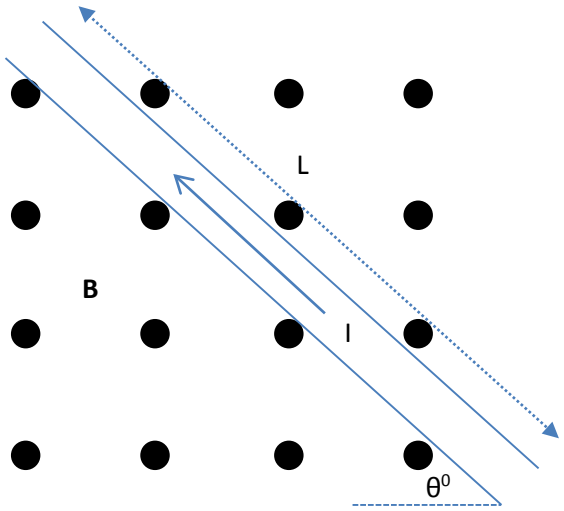
A) Predicting the speed of electromagnetic waves.

B) Providing an alternative view to the existence of the ether.

C) Experimentally discovering Maxwell's electromagnetic waves.

D) Providing the most accurate estimate for the speed of light.

6. A current carrying conductor of length L lies in a uniform magnetic field as shown. The current through the conductor is I and the magnetic field strength is B.



The magnitude of the force on the conductor is best given by:

A) ILB

B) ILB sin θ

C) ILB sin 45

D) 0

7. An observer on a high speed train travelling with a speed of 0.8 c notices two doors on the train open at the same time. In addition they also see the platform outside the train move from left to right. What would an observer on a platform outside the train see?

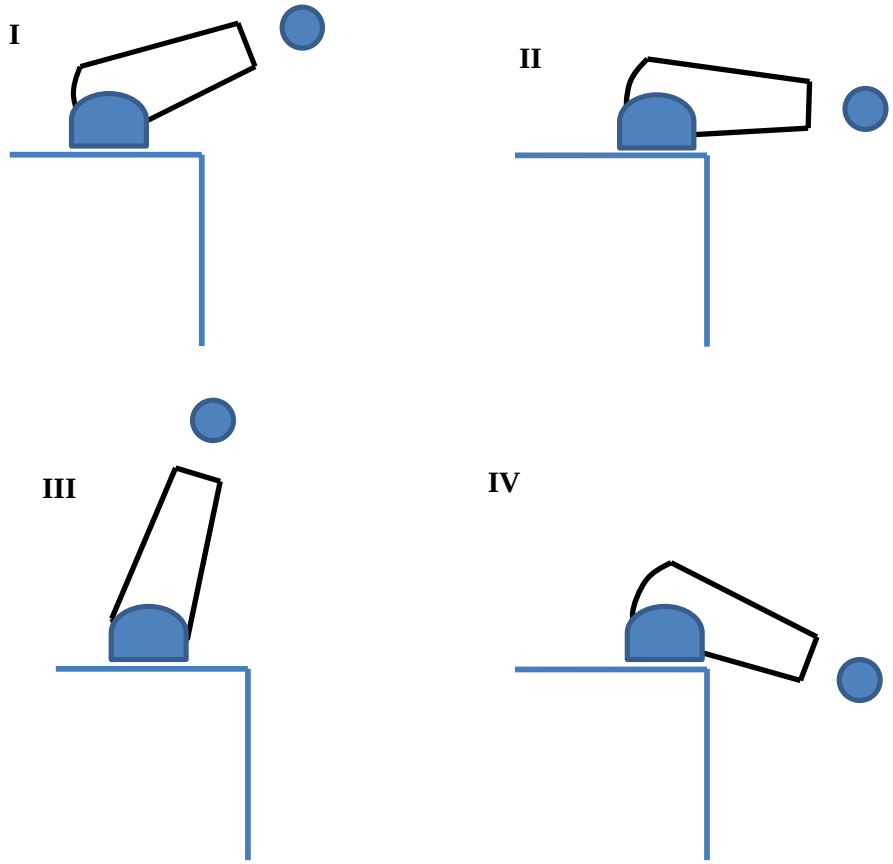
A) Both doors open simultaneously and the train moves from left to right.

B) Both doors do not open simultaneously and the train moves from left to right.

C) Both doors do not open simultaneously and the train moves from right to left.

D) Both doors open simultaneously and the train moves from right to left.

8. A cannon fires a ball from the top of a cliff at various angles as shown. For all situations the ball has been fired with the same speed.



It is true to say that

A) Angle IV will result in the greatest final speed just before it hits the ground.

B) Angle III will result in the greatest final speed.

C) Angle II will result in the ball having the same horizontal speed as in Angle I.

D) Angle II will result in the longest time of flight.

9. *"I occasionally enclosed the spark B in a dark case so as to more easily make the observations; and in so doing I observed that the maximum spark-length became decidedly smaller in the case than it was before."*

The process being referred to, in the quote above is:

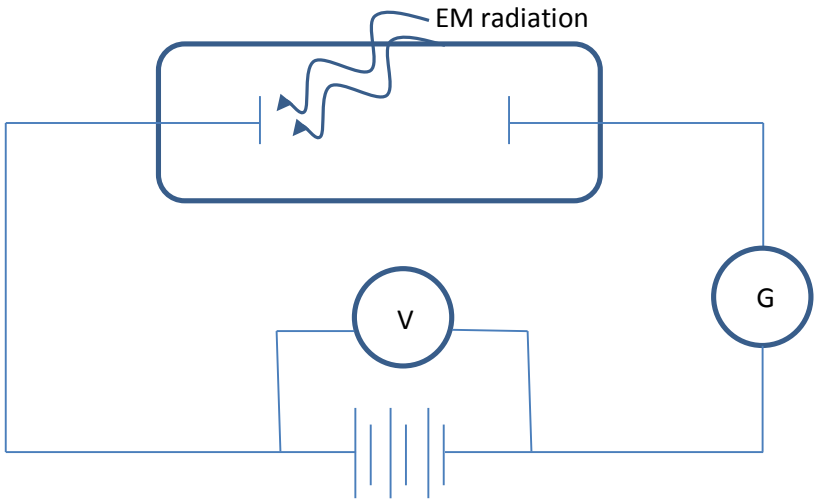
A) Photoelectric effect

B) Interference

C) Blackbody radiation

D) The aether

10. The following is a setup of the experiment used to investigate the phenomenon known as the photoelectric effect.



The aim of this particular experiment would be:

A) to determine the maximum kinetic energy of the electrons leaving the emitter.

B) to determine whether the intensity of the incident radiation was independent of the metal used.

C) to determine the stopping frequency of the power supply.

D) to determine the effect of temperature on photoemission.

11. Which of the following factors would least improve the efficiency of a transformer?

A) Choosing a “softer” iron core

B) Reducing the number of turns in the secondary coil

C) Laminating the core.

D) using AC instead of DC current.

12. When electricity is transmitted from the power station to households, it is transmitted at:

A) a high DC voltage and low current.

B) a low DC voltage and high current.

C) a high AC voltage and high current.

D) a high AC voltage and low current.

13. A Spaceship on a particular mission is required to take off from two planets; Buzz and Fuzz. The properties of each planet are shown below:

	Mass	Radius
Buzz	M	2R
Fuzz	2M	R

It is true to say that:

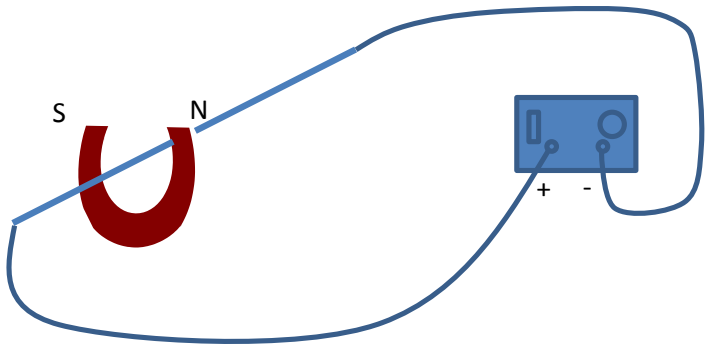
A) the escape velocity required at Buzz is twice that of the velocity required to escape Fuzz.

B) the escape velocity required at Fuzz is twice that of the velocity required to escape Buzz.

C) the escape velocity from both planets are equal.

D) the escape velocity required at Buzz is 1.4 that of the velocity required to escape Fuzz.

13.



A wire passes through a magnet as shown in the above sketch. As the switch on the power pack is turned on the wire moves:

A) up and out of the magnet

B) it doesn't move

C) down

D) sideways

14. The following table shows the work functions of various metals used to investigate the photoelectric effect.

Metal	Work Function (eV)
Platinum	6.35
Gold	5.10
Aluminium	4.08
Calcium	2.90
Potassium	2.30
Sodium	2.28

Radiation of wavelength 490nm and intensity of 5mW/m^2 is incident upon the emitter. The material of the emitter is varied during the experiment. Which of the following observations are to be expected?

A) If Sodium was replaced with Potassium then a higher photocurrent would result.

B) A large photocurrent would be detected for all metals used.

C) No stopping voltage is required for the metals of Potassium and Sodium.

D) Platinum produced significantly higher photocurrent than Gold.

16. A DC motor is spinning with constant speed. Which of the following is true?

A) replacing the bar magnets with a radial magnet will likely lead to a decrease in speed.

B) the Back EMF is approximately equal and opposite to the EMF of the power supply.

C) the rate of change of flux across the armature is a constant.

D) the supply EMF is constantly changing direction.

17. A spacecraft during a mission utilises the gravitational field of a planet. During a gravity assist manoeuvre which of the following factors remain unchanged?

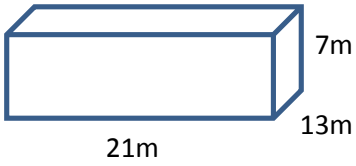
A) the speed of the craft relative to the planet

B) the planet's speed

C) the speed of the craft relative to the Sun

D) the direction of the craft.

18. A spacecraft in the shape of a rectangular prism with rest dimensions shown below is observed to be travelling at 0.9c. The volume and mass of the craft as calculated by a passenger on board the craft are $1911m^3$ and 1251kg respectively. What would the observer outside the craft calculate the new volume and mass of the craft to be?



Motion of craft as observed by an outsider.

	Volume (m^3)	Mass (kg)
A)	1911	1251
B)	833	1251
C)	833	2870
D)	1911	2870

19. Which of the following is true for the occupants of a space station orbiting the Earth?

A) the net force on the occupants must be zero.

B) the acceleration due to gravity for the astronauts is zero.

C) the magnitude of the acceleration of the astronauts is always changing.

D) the acceleration of the astronauts is the same as that of the space station.

20. The intensity vs wavelength curves emitted by "Black Body radiators" was best explained by which idea?

A) The energy of electromagnetic radiation could only be emitted and absorbed in discrete bundles.

B) Energy was proportional to frequency.

C) Ultraviolet radiation was made of particles.

D) Electrons could leave the surface of a material once exposed to radiation.

Part B – 60 Marks **Student Number …….**

Answer the questions in the spaces provided.

Show all relevant working in questions involving calculations.

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21. a) Describe a first-hand investigation you can do (or did) to determine the acceleration due to gravity on Earth. Include a diagram in your answer. [4]

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b) How would you assess the accuracy of the result of your investigation? [1]

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c) How would you increase the reliability of the data you collected? [1]

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d) How would you assess the reliability of the data collected? [1]

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22. A typical graph of the g-force of astronauts experienced from lift off to orbital insertion is shown below.

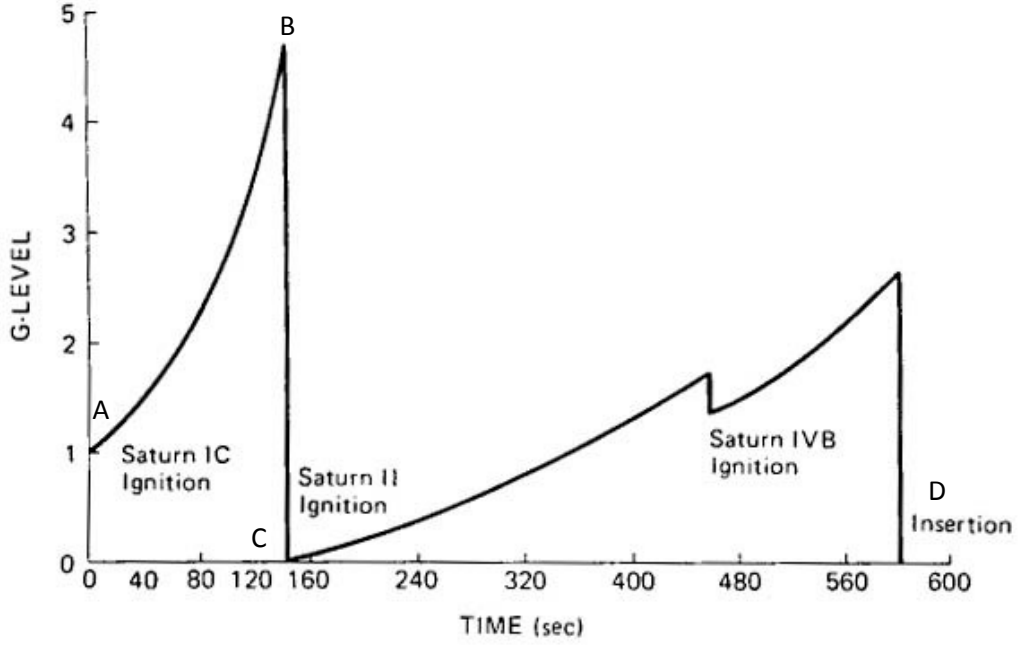

Figure 2. Typical Apollo launch profile – Saturn V launch vehicle.

Account for the shape of this graph with specific reference to points and/or the regions designated by the letters A, B, C and D. [5]

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23. Compare and Contrast the operation of a DC motor with an AC generator. Include diagram/s in your answer. [5]

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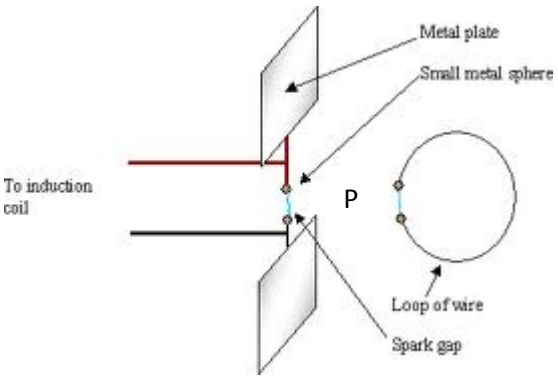
24. The diagram below is a representation of an experiment performed by Heinrich Hertz.



a) Identify the nature of the radiation at P. [1]

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b) Label on the above diagram the emitter and the receiver. [1]

c) Describe the effect of adding a sheet of glass in between the transmitter and receiver. [1]

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d) Which scientist was able to later explain what happened in (c)? [1]

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25. Clarify the assertion that the **change in** GPE of a spacecraft has more physical meaning than the actual GPE of that craft at any point in space and time. [3]

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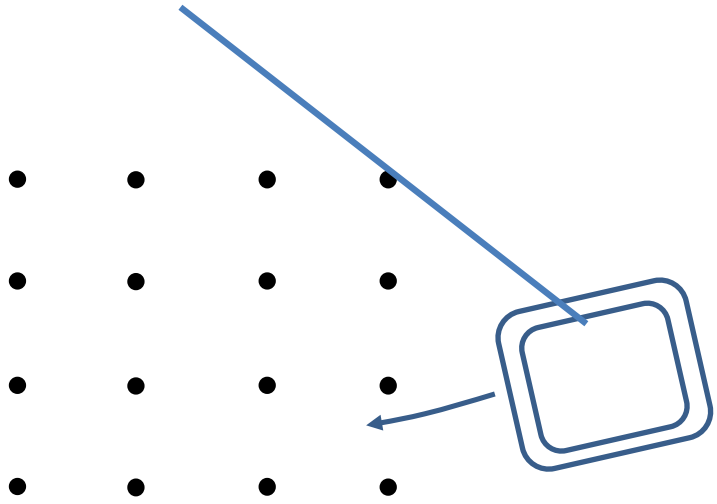
26. A metal ring conductor is free to swing into a magnetic field directed out of the page as shown.



a) Predict the path of the current in the metal ring at the instant shown justifying your answer. [2]

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Question cont'd over the page…

b) Describe what would happen as the ring is left to swing. Explain and account for all observations and assume that on the first swing the ring reaches the left edge of the field. [2]

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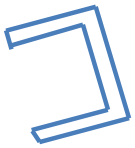
c) The ring is replaced with the metal shown below. Describe and account for any differences in the new motion of the metal shape and account for any differences. [2]



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27. a) By equating Centripetal Force with Gravity, show mathematically that the velocity of a satellite is independent of its mass. [2]

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b) A student is heard to say:

"since the velocity of a satellite for any given orbit is independent of mass, in order to get two satellites of different masses into the same orbit they each require the same amount of fuel."

Assess the accuracy of this statement. [4]

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28. On the planet Zara the acceleration due to gravity is one-tenth that of Earth's. A person on Zara throws a stone of mass 700g at an angle of 30^0 on a horizontal surface. The final **vertical** velocity of the stone is 20m/s.

a) Calculate the initial velocity of the stone. You may assume the person has zero height.

[2]

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b) Hence find the time of flight. [2]

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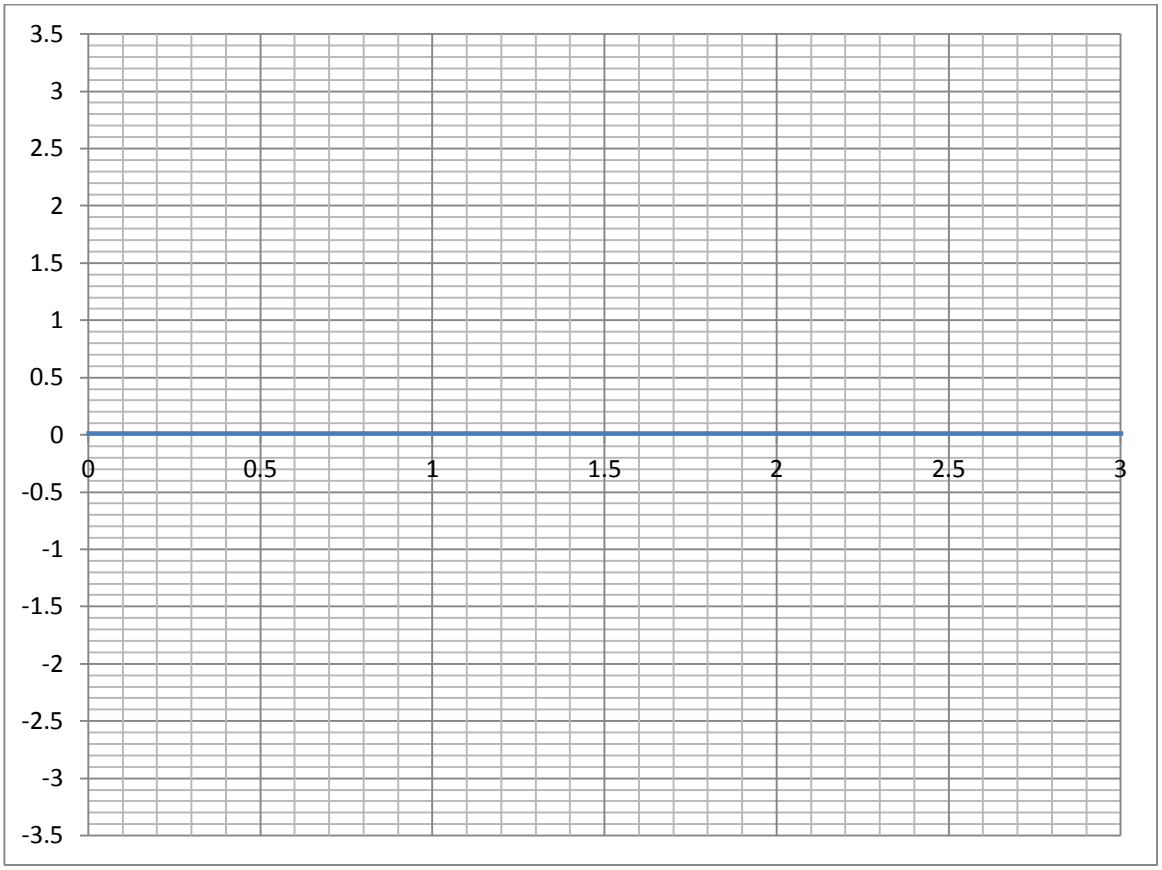
29. A student conducted an experiment to investigate the properties of the photoelectric effect. She obtained the following results.

Frequency ($x10^{14}$) Hz	KE_{max} (eV)
5.29	0.38
6.95	1.02
7.73	1.25
8.10	1.55
9.85	2.24
11.80	3.12

a) Plot the data on the grid provided below and fully label the axes. [3]



b) Estimate the threshold frequency and the work function of the material. [2]

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c) Explain the significance of the shape of the graph to our understanding of the photoelectric effect.

[3]

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30. When considering the ideas of motion, space and time, two main scientists come to mind; Isaac Newton and Albert Einstein.

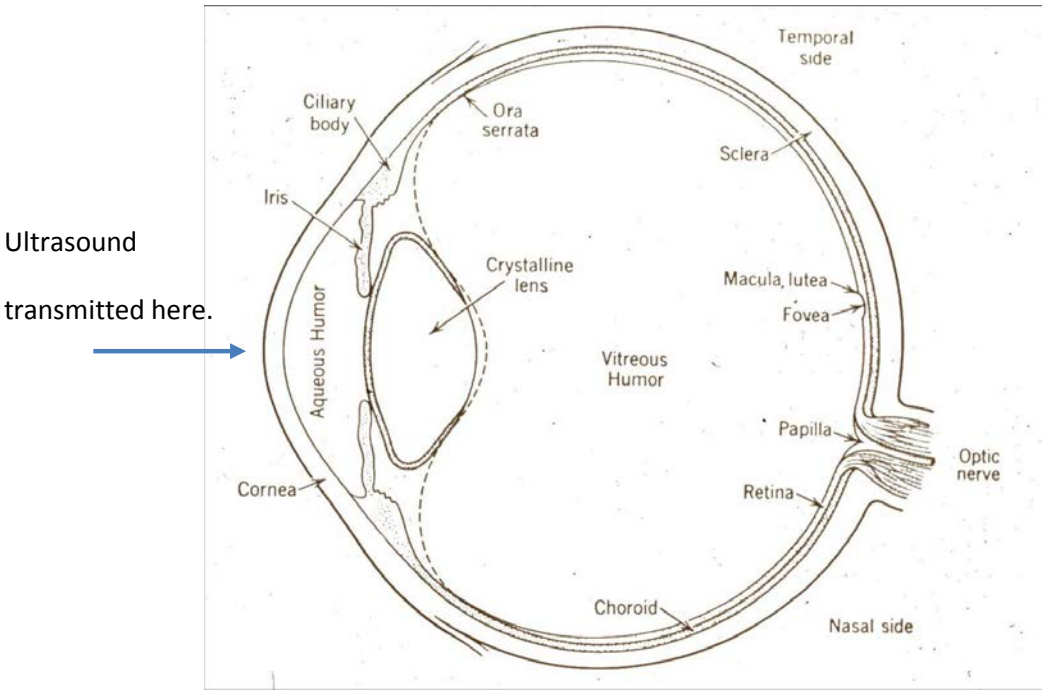
Compare and contrast Newton's ideas and Einstein's contributions to our understanding of motion, space and time, as well as the impact of their ideas to society. [5]

SECTION 2 Medical Physics (25 marks) - *write answers in the answer booklet provided.*

1. The table below shows the speed of sound in and density of several different tissues.

Tissue	Speed of sound in tissue (m/s)	Density (kg/m^3)	Acoustic Impedance (X 10^6 Rayls)
Blood	1575	1055	1.66
Water (aqueous humour)	1480	1000	1.48
Fat	1450	950	1.38
Eye (lens)	1650	1040	1.72
Eye (vitreous humour)	1525	1010	
Bone (axial)	2800	1900	5.32

The cross sectional diagram of the eye is shown below:



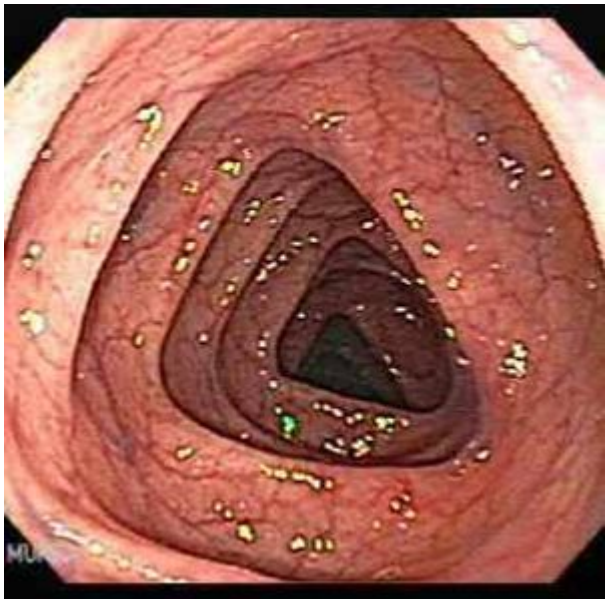
a) Using the above table calculate the acoustic impedance of vitreous humour. [2]

b) Hence calculate the percentage reflection of ultrasound at the lens/vitreous humour boundary.

[2]

c) Justify the use of ultrasound to image an organ such as the eye. [3]

2.



The following image was taken during a colleenoscopy (sorry I meant to write colonoscopy ☺), in other words an examination of the colon or large intestine. Describe how optic fibres are used to produce an image such as the one shown. [3]

3. Justify the use of a contrast agent such as a Barium meal when performing X ray examinations.

[3]

4. Compare and contrast the use of PET and CT scans in medical diagnosis. [6]

5. “An understanding of the nature of light and other forms of electromagnet radiation was crucial in the development of imaging technologies such as MRI, X rays and others.”

Evaluate this statement. [6]

DATA SHEET

Charge on electron, q_e	-1.602×10^{-19} C
Mass of electron, m_e	9.109×10^{-31} kg
Mass of neutron, m_n	1.675×10^{-27} kg
Mass of proton, m_p	1.673×10^{-27} kg
Speed of sound in air	340 m s^{-1}
Earth's gravitational acceleration, g	9.8 m s^{-2}
Speed of light, c	3.00×10^8 m s^{-1}
Magnetic force constant, $\left(k \equiv \frac{\mu_0}{2\pi}\right)$	2.0×10^{-7} N A^{-2}
Universal gravitational constant, G	6.67×10^{-11} N m^2 kg^{-2}
Mass of Earth	6.0×10^{24} kg
Planck constant, h	6.626×10^{-34} J s
Rydberg constant, R (hydrogen)	1.097×10^7 m^{-1}
Atomic mass unit, u	1.661×10^{-27} kg 931.5 MeV/c^2
1 eV	1.602×10^{-19} J
Density of water, ρ	1.00×10^3 kg m^{-3}
Specific heat capacity of water	4.18×10^3 J kg^{-1} K^{-1}

FORMULAE SHEET

$v = f\lambda$

$I \propto \frac{1}{d^2}$

$\frac{v_1}{v_2} = \frac{\sin i}{\sin r}$

$E = \frac{F}{q}$

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

$P = VI$

Energy $= VIt$

$v_{av} = \frac{\Delta r}{\Delta t}$

$a_{av} = \frac{\Delta v}{\Delta t}$ therefore $a_{av} = \frac{v-u}{t}$

$\Sigma F = ma$

$F = \frac{mv^2}{r}$

$E_k = \frac{1}{2}mv^2$

$W = Fs$

$p = mv$

Impulse $= Ft$

$E_p = -G\frac{m_1 m_2}{r}$

$F = mg$

$v_x^2 = u_x^2$

$v = u + at$

$v_y^2 = u_y^2 + 2a_y\Delta y$

$\Delta x = u_x t$

$\Delta y = u_y t + \frac{1}{2}a_y t^2$

$\frac{r^3}{T^2} = \frac{GM}{4\pi^2}$

$F = \frac{Gm_1 m_2}{d^2}$

$E = mc^2$

$l_v = l_0\sqrt{1-\frac{v^2}{c^2}}$

$t_v = \frac{t_0}{\sqrt{1-\frac{v^2}{c^2}}}$

$m_v = \frac{m_0}{\sqrt{1-\frac{v^2}{c^2}}}$

FORMULAE SHEET

$$\frac{F}{l} = k\frac{I_1 I_2}{d}$$

$$F = BIl\sin\theta$$

$$\tau = Fd$$

$$\tau = nBIA\cos\theta$$

$$\frac{V_p}{V_s} = \frac{n_p}{n_s}$$

$$d = \frac{1}{p}$$

$$M = m - 5\log\left(\frac{d}{10}\right)$$

$$\frac{I_A}{I_B} = 100^{(m_B - m_A)/5}$$

$$m_1 + m_2 = \frac{4\pi^2 r^3}{GT^2}$$

$$F = qvB\sin\theta$$

$$E = \frac{V}{d}$$

$$E = hf$$

$$c = f\lambda$$

$$\frac{1}{\lambda} = R\left(\frac{1}{n_f^2} - \frac{1}{n_i^2}\right)$$

$$\lambda = \frac{h}{mv}$$

$$Z = \rho v$$

$$\frac{I_r}{I_0} = \frac{\left[Z_2 - Z_1\right]^2}{\left[Z_2 + Z_1\right]^2}$$

$$A_0 = \frac{V_{\text{out}}}{V_{\text{in}}}$$

$$\frac{V_{\text{out}}}{V_{\text{in}}} = -\frac{R_{\text{f}}}{R_{\text{i}}}$$

PERIODIC TABLE OF THE ELEMENTS

KEY

Atomic Number — 79 Au — Symbol of element

Atomic Weight — 197.0 Gold — Name of element

1 H 1.008 Hydrogen																	2 He 4.003 Helium
3 Li 6.941 Lithium	4 Be 9.012 Beryllium											5 B 10.81 Boron	6 C 12.01 Carbon	7 N 14.01 Nitrogen	8 O 16.00 Oxygen	9 F 19.00 Fluorine	10 Ne 20.18 Neon
11 Na 22.99 Sodium	12 Mg 24.31 Magnesium											13 Al 26.98 Aluminium	14 Si 28.09 Silicon	15 P 30.97 Phosphorus	16 S 32.07 Sulfur	17 Cl 35.45 Chlorine	18 Ar 39.95 Argon
19 K 39.10 Potassium	20 Ca 40.08 Calcium	21 Sc 44.96 Scandium	22 Ti 47.87 Titanium	23 V 50.94 Vanadium	24 Cr 52.00 Chromium	25 Mn 54.94 Manganese	26 Fe 55.85 Iron	27 Co 58.93 Cobalt	28 Ni 58.69 Nickel	29 Cu 63.55 Copper	30 Zn 65.41 Zinc	31 Ga 69.72 Gallium	32 Ge 72.64 Germanium	33 As 74.92 Arsenic	34 Se 78.96 Selenium	35 Br 79.90 Bromine	36 Kr 83.80 Krypton
37 Rb 85.47 Rubidium	38 Sr 87.62 Strontium	39 Y 88.91 Yttrium	40 Zr 91.22 Zirconium	41 Nb 92.91 Niobium	42 Mo 95.94 Molybdenum	43 Tc [97.91] Technetium	44 Ru 101.1 Ruthenium	45 Rh 102.9 Rhodium	46 Pd 106.4 Palladium	47 Ag 107.9 Silver	48 Cd 112.4 Cadmium	49 In 114.8 Indium	50 Sn 118.7 Tin	51 Sb 121.8 Antimony	52 Te 127.6 Tellurium	53 I 126.9 Iodine	54 Xe 131.3 Xenon
55 Cs 132.9 Caesium	56 Ba 137.3 Barium	57–71 Lanthanides	72 Hf 178.5 Hafnium	73 Ta 180.9 Tantalum	74 W 183.8 Tungsten	75 Re 186.2 Rhenium	76 Os 190.2 Osmium	77 Ir 192.2 Iridium	78 Pt 195.1 Platinum	79 Au 197.0 Gold	80 Hg 200.6 Mercury	81 Tl 204.4 Thallium	82 Pb 207.2 Lead	83 Bi 209.0 Bismuth	84 Po [209.0] Polonium	85 At [210.0] Astatine	86 Rn [222.0] Radon
87 Fr [223.0] Francium	88 Ra [226.0] Radium	89–103 Actinides	104 Rf [261.1] Rutherfordium	105 Db [262.1] Dubnium	106 Sg [266.1] Seaborgium	107 Bh [264.1] Bohrium	108 Hs [277] Hassium	109 Mt [268] Meitnerium	110 Ds [271] Darmstadtium	111 Rg [272] Roentgenium							

Lanthanides

57 La 138.9 Lanthanum	58 Ce 140.1 Cerium	59 Pr 140.9 Praseodymium	60 Nd 144.2 Neodymium	61 Pm [144.9] Promethium	62 Sm 150.4 Samarium	63 Eu 152.0 Europium	64 Gd 157.3 Gadolinium	65 Tb 158.9 Terbium	66 Dy 162.5 Dysprosium	67 Ho 164.9 Holmium	68 Er 167.3 Erbium	69 Tm 168.9 Thulium	70 Yb 173.0 Ytterbium	71 Lu 175.0 Lutetium

Actinides

89 Ac [227.0] Actinium	90 Th 232.0 Thorium	91 Pa 231.0 Protactinium	92 U 238.0 Uranium	93 Np [237.0] Neptunium	94 Pu [244.1] Plutonium	95 Am [243.1] Americium	96 Cm [247.1] Curium	97 Bk [247.1] Berkelium	98 Cf [251.1] Californium	99 Es [252.1] Einsteinium	100 Fm [257.1] Fermium	101 Md [258.1] Mendelevium	102 No [259.1] Nobelium	103 Lr [262.1] Lawrencium

Where the atomic weight is not known, the relative atomic mass of the most common radioactive isotope is shown in brackets.
The atomic weights of Np and Tc are given for the isotopes ^{237}Np and ^{99}Tc.

Multiple Choice Answer Sheet **Student number……**

	A	B	C	D
1	⬭	⬭	⬭	⬭
2	⬭	⬭	⬭	⬭
3	⬭	⬭	⬭	⬭
4	⬭	⬭	⬭	⬭
5	⬭	⬭	⬭	⬭
6	⬭	⬭	⬭	⬭
7	⬭	⬭	⬭	⬭
8	⬭	⬭	⬭	⬭
9	⬭	⬭	⬭	⬭
10	⬭	⬭	⬭	⬭
11	⬭	⬭	⬭	⬭
12	⬭	⬭	⬭	⬭
13	⬭	⬭	⬭	⬭
14	⬭	⬭	⬭	⬭
15	⬭	⬭	⬭	⬭
16	⬭	⬭	⬭	⬭
17	⬭	⬭	⬭	⬭
18	⬭	⬭	⬭	⬭
19	⬭	⬭	⬭	⬭
20	⬭	⬭	⬭	⬭

Ascham School

Trial Examination 2013

Physics

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1. The motor effect occurs when:

A) A current carrying conductor experiences a force in a magnetic field

B) A motor is briefly prevented from spinning

C) A stationary charge experiences a force in a magnetic field

D) The effect of a current carrying conductor on a magnetic field causes attraction between the conductor and field.

2. A satellite of mass M has an orbital period of 24 hours at an altitude of R. The orbital period of another satellite of mass 2M at an altitude of 3R is closest to:

A) 48 hours

B) 12 hours

C) 24 hours

D) 68 hours

3. The aim of the Michelson Morley experiment was to:

A) Prove the existence of the aether.

B) Measure the speed of the Earth relative to the aether.

C) Determine the interference pattern between two lasers.

D) establish a null result.

4. Given that the range of wavelengths for UV light is between 400nm and 10nm, then the maximum energy of a photon of UV light is closest to:

A) 1.98×10^{-17} J

B) 4.97×10^{-19} J

C) 3.00×10^{8} J

D) 6.63×10^{-34} Js

5. Heinrich Hertz is best remembered for:

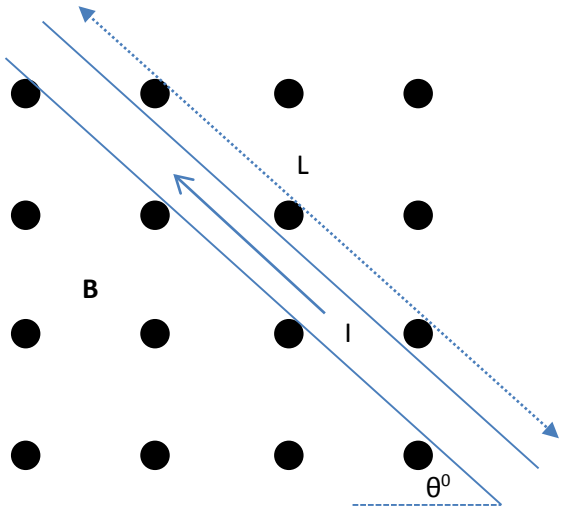
A) Predicting the speed of electromagnetic waves.

B) Providing an alternative view to the existence of the ether.

C) Experimentally discovering Maxwell's electromagnetic waves.

D) Providing the most accurate estimate for the speed of light.

6. A current carrying conductor of length L lies in a uniform magnetic field as shown. The current through the conductor is I and the magnetic field strength is B.



The magnitude of the force on the conductor is best given by:

A) ILB

B) ILB sin θ

C) ILB sin 45

D) 0

7. An observer on a high speed train travelling with a speed of 0.8 c notices two doors on the train open at the same time. In addition they also see the platform outside the train move from left to right. What would an observer on a platform outside the train see?

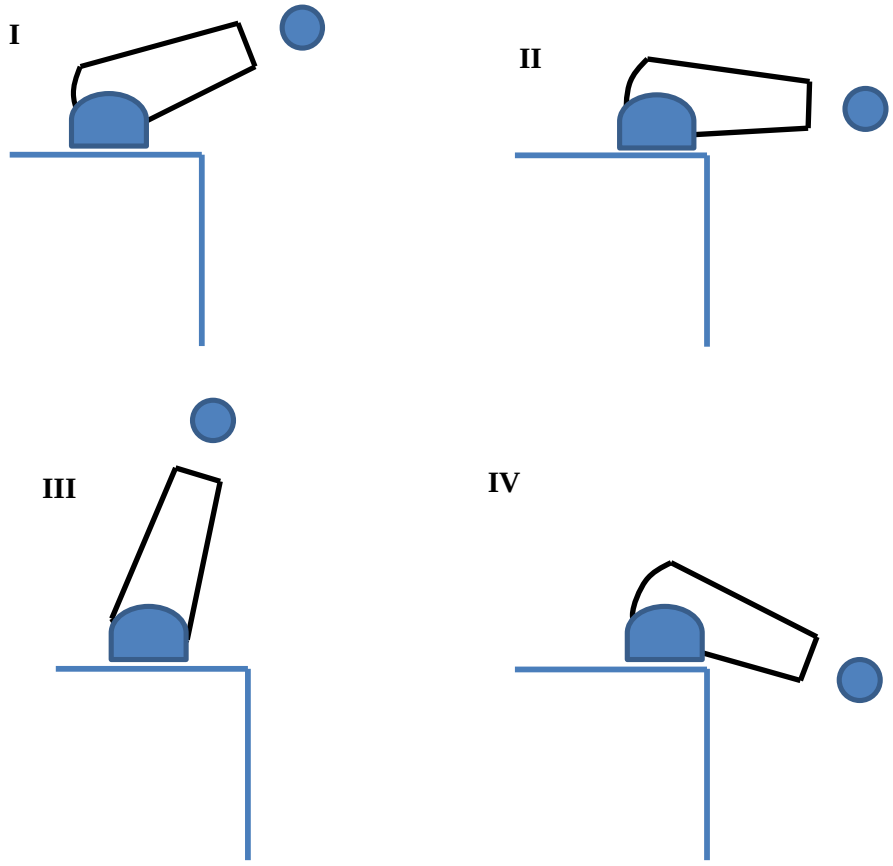
A) Both doors open simultaneously and the train moves from left to right.

B) Both doors do not open simultaneously and the train moves from left to right.

C) Both doors do not open simultaneously and the train moves from right to left.

D) Both doors open simultaneously and the train moves from right to left.

8. A cannon fires a ball from the top of a cliff at various angles as shown. For all situations the ball has been fired with the same speed.



It is true to say that

A) Angle IV will result in the greatest final speed just before it hits the ground.

B) Angle III will result in the greatest final speed.

C) Angle II will result in the ball having the same horizontal speed as in Angle I.

D) Angle II will result in the longest time of flight.

9. *"I occasionally enclosed the spark B in a dark case so as to more easily make the observations; and in so doing I observed that the maximum spark-length became decidedly smaller in the case than it was before."*

The process being referred to, in the quote above is:

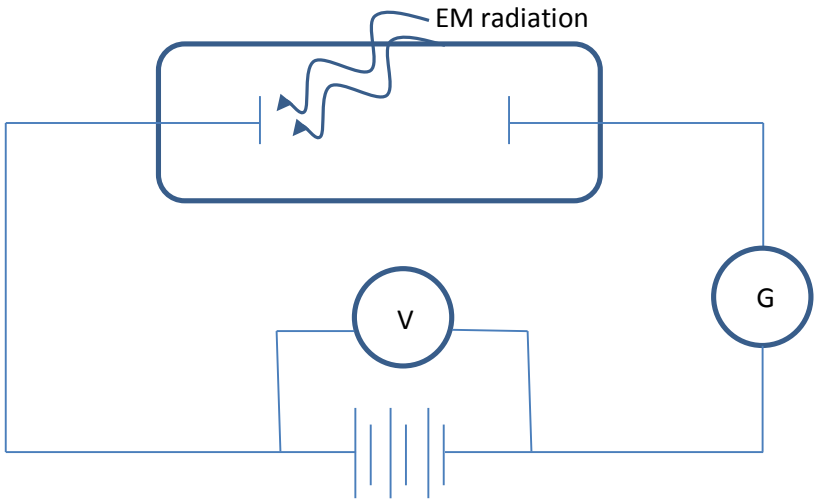
A) Photoelectric effect

B) Interference

C) Blackbody radiation

D) The aether

10. The following is a setup of the experiment used to investigate the phenomenon known as the photoelectric effect.



The aim of this particular experiment would be:

A) to determine the stopping frequency of the power supply.

B) to determine whether the intensity of the incident radiation was independent of the metal used.

C) to determine the maximum kinetic energy of the electrons leaving the emitter.

D) to determine the effect of temperature on photoemission.

11. Which of the following factors would least improve the efficiency of a transformer?

A) Choosing a softer iron core

B) Reducing the number of turns in the secondary coil

C) Laminating the core.

D) using an AC instead of a DC current.

12. When electricity is transmitted from the power station to households, it is transmitted at:

A) a high DC voltage and low current.

B) a low DC voltage and high current.

C) a high AC voltage and high current.

D) a high AC voltage and low current.

13. A Spaceship on a particular mission is required to take off from two planets; Buzz and Fuzz. Some of the properties of each planet are shown below:

	Mass	Radius
Buzz	M	2R
Fuzz	2M	R

It is true to say that:

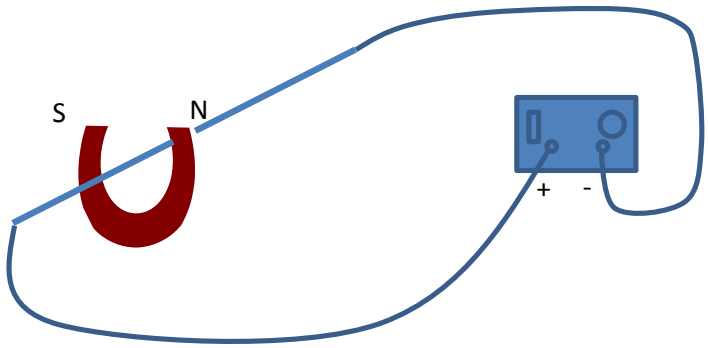
A) the escape velocity required at Buzz is twice that of the velocity required to escape Fuzz.

B) the escape velocity required at Fuzz is twice that of the velocity required to escape Buzz.

C) the escape velocity from both planets are equal.

D) the escape velocity required at Buzz is 1.4 that of the velocity required to escape Fuzz.

13.



A wire passes through a magnet as shown in the above sketch. As the switch on the power pack is turned on the wire moves:

A) down

B) it doesn't move

C) up and out of the magnet

D) sideways

14. The following table shows the work functions of various metals used to investigate the photoelectric effect.

Metal	Work Function (eV)
Platinum	6.35
Gold	5.10
Aluminium	4.08
Calcium	2.90
Potassium	2.30
Sodium	2.28

Radiation of wavelength 490nm and intensity of 5mW/m^2 is incident upon the emitter. The material of the emitter is varied during the experiment. Which of the following observations are to be expected?

A) If Sodium was replaced with Potassium then a higher photocurrent would result.

B) A large photocurrent would be detected for all metals used.

C) No stopping voltage is required for metals other than Potassium and Sodium.

D) Platinum produced significantly higher photocurrent than Gold.

16. A DC motor is spinning with constant speed. Which of the following is true?

A) replacing the bar magnets with a radial magnet will likely lead to a decrease in speed.

B) the Back EMF is approximately equal and opposite to the EMF of the power supply.

C) the rate of change of flux across the armature is a constant.

D) the supply EMF is constantly changing direction.

17. A spacecraft during a mission utilises the gravitational field of a planet. During a gravity assist manoeuvre which of the following factors remain unchanged?

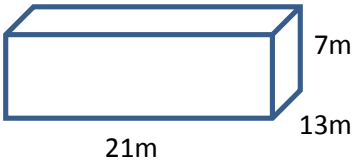
A) the speed of the craft relative to the planet

B) the planet's speed

C) the speed of the craft relative to the Sun

D) the direction of the craft.

18. A spacecraft in the shape of a rectangular prism with rest dimensions shown below is observed to be travelling at 0.9c. The volume and mass of the craft as calculated by a passenger on board the craft are 1911m^3 and 1251kg respectively. What would the observer outside the craft calculate the new volume and mass of the craft to be?



Motion of craft as observed by an outsider.

	Volume (m^3)	Mass (kg)
A)	1911	1251
B)	833	1251
C)	833	2870
D)	1911	2870

19. Which of the following is true for the occupants of a space station orbiting the Earth?

A) the net force on the occupants must be zero.

B) the acceleration due to gravity for the astronauts is zero.

C) the magnitude of the acceleration of the astronauts is always changing.

D) the acceleration of the astronauts is the same as that of the space station.

20. The intensity vs wavelength curves emitted by Black Body radiators was best explained by which idea?

A) The energy of electromagnetic radiation could only be emitted and absorbed in discrete bundles.

B) Energy was proportional to frequency.

C) Ultraviolet radiation was made of particles.

D) Electrons could leave the surface of a material once exposed to radiation.

Part B – 55 Marks **Student Number …….**

Answer the questions in the spaces provided.

Show all relevant working in questions involving calculations.

---

21. a) Describe a first-hand investigation you can do (or did) to determine the acceleration due to gravity on Earth. Include a diagram in your answer. [5]

Eg. Pendulum experiment or dropping a picket fence through a set of photogates.

- Student must include a clearly labelled diagram.
- Student must clearly explain how g was measured using a graph.
- Mention of the use of the gradient and how it relates to relevant formulae required.

b) How would you assess the accuracy of the result of your investigation? [1]

Compare with known values of g eg. From text.

c) How would you increase the reliability of the data you collected? [1]

Repeat the experiment several times

d) How would you assess the reliability of the data collected? [1]

Determine the spread of scores around an average value and look for similarities in the data obtained.

22. A typical graph of the g-force of astronauts experienced from lift off to orbital insertion is shown below.

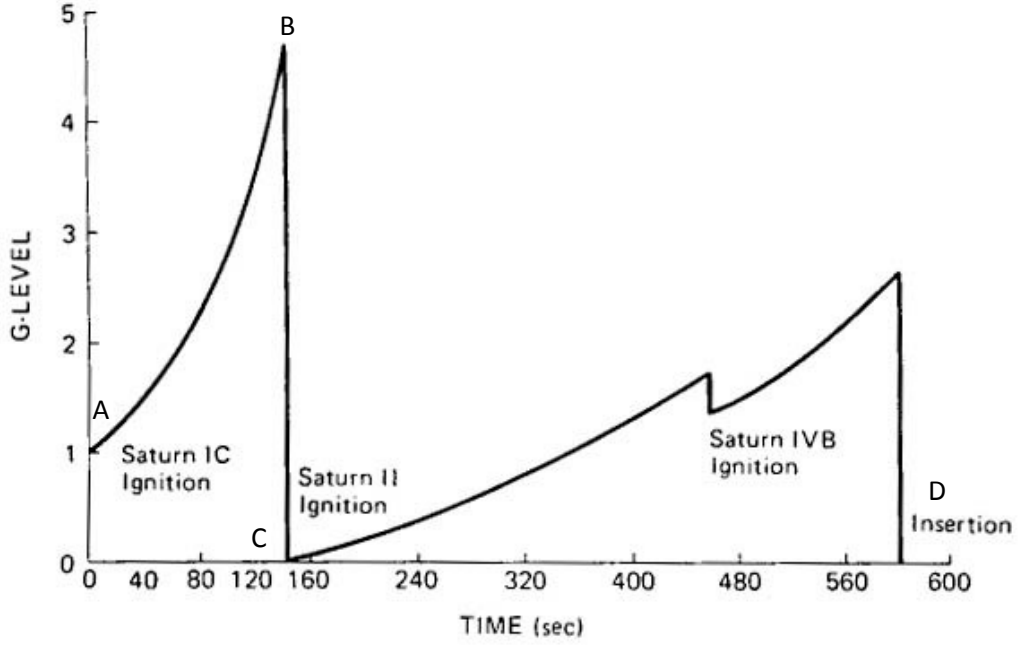


Figure 2. Typical Apollo launch profile – Saturn V launch vehicle.

Account for the shape of this graph with specific reference to points and/or the regions designated by the letters A, B, C and D. [5]

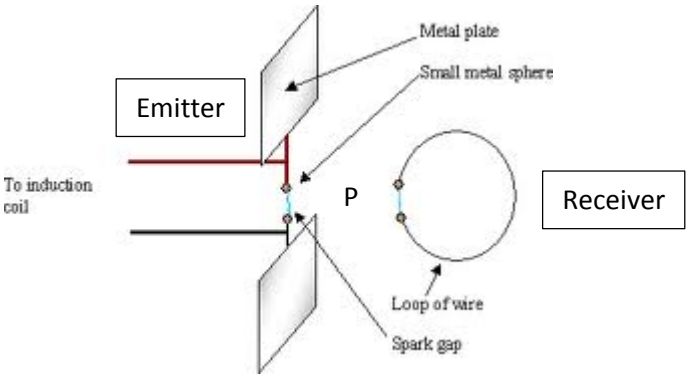
Student:	Mark Awarded
- Accounts for the value of g=1 at rest via some type of equation eg. G force = $\frac{a+g}{9.8}$ - Accounts for the increasing function and non-linearity of the curve by making reference to decreasing mass of the craft due to loss of fuel. - Accounts for the drop in g-level down to a value of 0 by referring to loss of a fuel stage. - Makes reference to all objects in freefall during insertion point explaining the value of g level = 0.	5

- Does not account for the value of g at any point via some type of equation eg. G force = $\frac{a+g}{9.8}$ or - Accounts for the above but does not account for the increasing function and non-linearity of the curve by making reference to decreasing mass of the craft due to loss of fuel. - Accounts for the drop in g-level down to a value of 0 by referring to loss of a fuel stage. - Makes reference to all objects in freefall during insertion point explaining the value of g level = 0.	4
- Does not account for the value of g at any point via some type of equation eg. G force = $\frac{a+g}{9.8}$ - Does not account for the increasing function and non-linearity of the curve by making reference to decreasing mass of the craft due to loss of fuel. - Accounts for the drop in g-level down to a value of 0 by referring to loss of a fuel stage. - Does not make reference to all objects in freefall during insertion point explaining the value of g level = 0.	3
- Shows little understanding of what g forces are. - Fails to explain adequately the shape of certain points on the graph.	1-2

23. Compare and Contrast the operation of a DC motor with an AC generator. Include diagram/s in your answer. [5]

Student:	Mark Awarded
- Includes at least 3 differences between the two. Eg. Inputs and outputs, commutators, direction of voltage. - Includes at least 1 similarity eg. Similar structure. - Diagrams are clear and fully labelled. - No contradictions present.	5
- Includes at least 2 differences between the two. Eg. Inputs and outputs, commutators, direction of voltage. - Includes at least 1 similarity eg. Similar structure. - Diagrams are clear and fully labelled. - No contradictions present. Or above criteria for 5 marks are met but 1 contradiction present.	4
- Includes at least 2 differences between the two. Eg. Inputs and outputs, commutators, direction of voltage. - No similarities - Diagrams are not clear or not fully labelled. - Contradictions present.	3
- Shows little understanding of the operation of each device. - Contradictions are present. - Diagrams are poorly drawn.	1-2

24. The diagram below is a representation of an experiment performed by Heinrich Hertz.



a) Identify the nature of the radiation at P. [1]

Radio waves, EMR etc..

.....

b) Label on the above diagram the emitter and the receiver. [1]

c) Describe the effect of adding a sheet of glass in between the transmitter and receiver. [1]

Glass blocks out UV and so the necessary spark gap became smaller.

.....

.....

.....

d) Which scientist was able to later explain what happened in (c)? [1]

Einstein

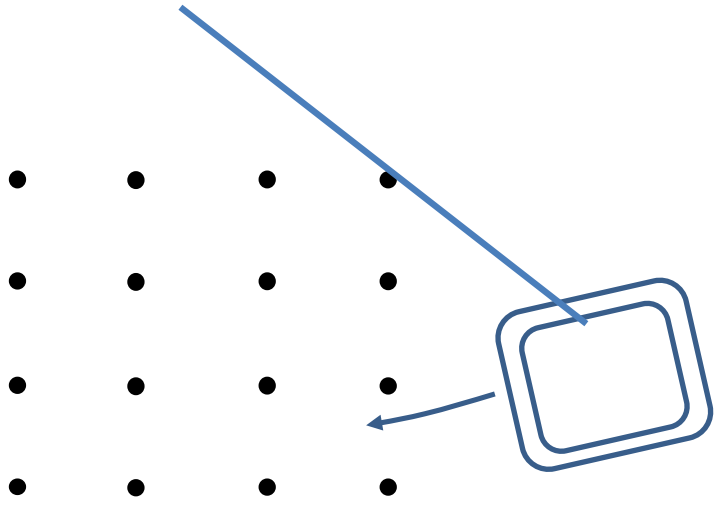
.....

25. Clarify the assertion that the **change in** GPE of a spacecraft has more physical meaning than the actual GPE of that craft at any point in space and time. Give specific references to mission planning and spacecraft manoeuvres. [3]

Students answers must include:

- *GPE in itself has limited physical meaning.*
- *Changes in GPE have more physical meaning since it gives an indication of the amount of fuel required for any particular journey. The more fuel carried on board means the more energy is required to accelerate the craft to the required speeds.*
- *Mission planners must take energy changes into account when planning trips.*

26. A metal ring conductor is free to swing into a magnetic field directed out of the page as shown.



a) Predict the path of the current in the metal ring as it enters the field. Justify your answer. [2]

- *Clockwise*
- *Change in flux produces field lines out of the loop.*
- *According to Lenz's Law the current induced will be in such a direction as to oppose this change.*

Question cont'd over the page…

b) Describe what would happen as the ring is left to swing. Explain and account for all observations (when the ring is in the field then out of the field again etc) and assume that on the first swing the ring reaches the left edge of the field. [3]

<u>As ring approaches:</u>

As before so ring experiences retarding force.

<u>Whilst in field:</u>

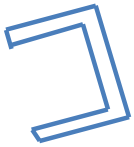
No change in flux so no retarding force.

<u>As ring leaves:</u>

Current induced is no anti-clockwise and ring experiences retarding force.

Thus the ring will slow down and eventually come to a stop.

c) The ring is replaced with the metal shown below. Describe and account for any differences in the new motion of the metal shape and account for any differences. [2]



The ring is now an open circuit so no measurable current will be induced.

The metal ring in this case will slow down only due to friction effects and will take a greater time for it to come to a stop.

27. a) By equating Centripetal Force with Gravity, show mathematically that the velocity of a satellite is independent of its mass. [2]

$$F = \frac{Gm_s m_{planet}}{r^2}$$

$$F = \frac{m_s v^2}{r}$$

$$\frac{m_s v^2}{r} = \frac{Gm_s m_{planet}}{r^2}$$

Leads to $v = \sqrt{\frac{Gm_{planet}}{r}}$

Which is independent of the mass of the satellite. Students must clearly show the cancellation of the mass of the satellite.

b) A student is heard to say:

"since the velocity of a satellite for any given orbit is independent of mass, in order to get two satellites of different masses into the same orbit they each require the same amount of fuel."

Assess the accuracy of this statement. [4]

This statement is inaccurate [1]

The required velocity of an orbiting satellite is indeed independent of its mass but satellites with different masses will require different amounts of fuel in order for the satellites to reach the required altitudes as well as the required velocity. [1]

During take off a heavier satellite will require more fuel than a lighter one in order to achieve the same velocities and this is true at every part of its journey. [1]

According to Newton's second law

$a = \frac{F_{net}}{m}$ [1]

And for satellites with higher mass a larger net force is required and hence more fuel.

28. On the planet Zara the acceleration due to gravity is one-tenth that of Earth's. A person on Zara throws a stone of mass 700g at an angle of 30^0 on a horizontal surface. The final **vertical** velocity of the stone is 20m/s.

a) Calculate the initial velocity of the stone. You may assume the person has zero height and take into account the symmetrical nature of the stone's motion. [2]

Due to symmetry

Final angle of impact is also 30 degrees, therefore, using trigonometry final velocity of stone is 20/sin30 = 40m/s

Initial velocity is 40m/s at 30 degrees to the horizontal.

b) Hence find the time of flight. [2]

Time to max height make v = 0 for vertical motion:

v = u – gt

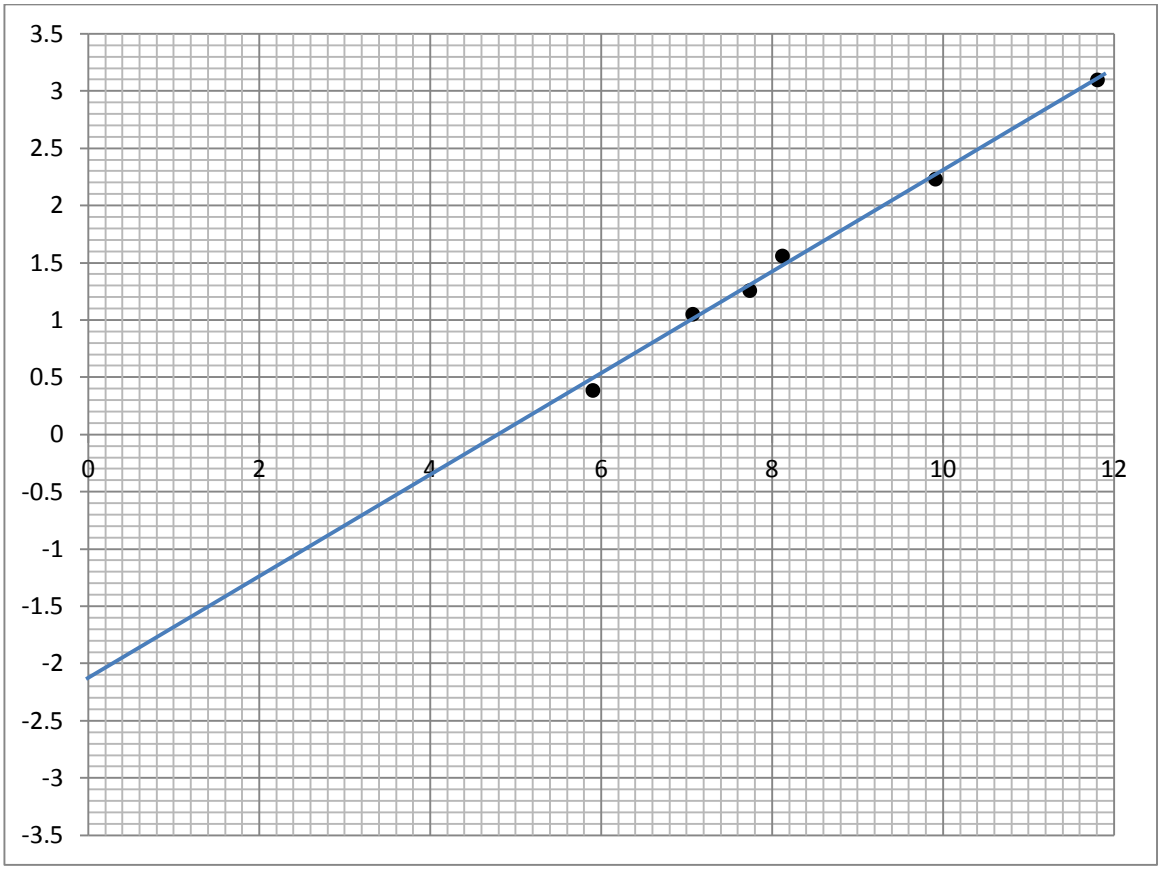
0 = 20 – (9.8/10)t

t = 20.41 seconds

therefore time of flight is 40.8 seconds.

29. A student conducted an experiment to investigate the properties of the photoelectric effect. She obtained the following results.

Frequency (x10^{14}) Hz	KE_{max} (eV)
5.29	0.38
6.95	1.02
7.73	1.25
8.10	1.55
9.85	2.24
11.80	3.12



a) Plot the data on the grid provided below and fully label the axes. [3]

b) Estimate the threshold frequency and the work function of the material. [2]

The threshold frequency is 4.85 x 10^{14}Hz and the work function is 2.1 eV

c) Explain the significance of the shape of the graph to our understanding of the photoelectric effect.

[3]

According to Einstein

KE_{max} = hf – Work function

Which is linear…

……

……

……

30. A student is heard to say:

"Einstein's ideas about space, time and the motion of objects at near speeds of light are a fairy tale as they contradict common sense and there is no real evidence to support it. "

Evaluate this statement. [5]

Student:	Mark Awarded
- Includes VJ - Acknowledges that Einstein's ideas do appear to contradict common sense as relativistic effects are not observed or detected at everyday speeds. - Provides at least 2 examples of evidence supporting Einstein's theories. Eg. Atomic clocks and Muons.	5
- Includes VJ - No Acknowledgement that Einstein's ideas do appear to contradict common sense as relativistic effects are not observed or detected at everyday speeds. - Provides at least 2 examples of evidence supporting Einstein's theories. Eg. Atomic clocks and Muons.	4
- Includes VJ - No Acknowledgement that Einstein's ideas do appear to contradict common sense as relativistic effects are not observed or detected at everyday speeds. - Provides only 1 example of evidence supporting Einstein's theories. Eg. Atomic clocks and Muons.	3
- Includes VJ - No Acknowledgement that Einstein's ideas do appear to contradict common sense as relativistic effects are not observed or detected at everyday speeds. - Provides no examples of evidence supporting Einstein's theories. Or the evidence provided is inaccurate.	1-2

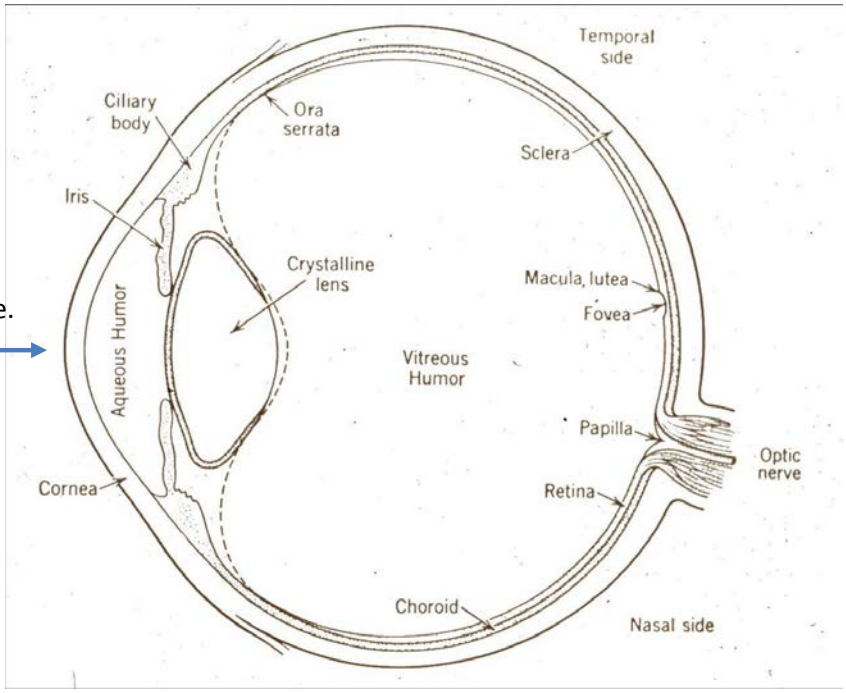
SECTION 2 Medical Physics (25 marks) - *write answers in the answer booklet provided.*

1. The table below shows the speed of sound in and density of several different tissues.

Tissue	Speed of sound in tissue (m/s)	Density (kg/m^3)	Acoustic Impedance (X 10^6 Rayls)
Blood	1575	1055	1.66
Water (aqueous humour)	1480	1000	1.48
Fat	1450	950	1.38
Eye (lens)	1650	1040	1.72
Eye (vitreous humour)	1525	1010	
Bone (axial)	2800	1900	5.32

The cross sectional diagram of the eye is shown below:

Ultrasound transmitted here.



a) Using the above table calculate the acoustic impedance of vitreous humour. [2]

Z = pv

= 1010 x 1525 [1]

= 1.54 x 10^6 Rayls [1]

b) Hence calculate the percentage reflection of ultrasound at the lens/vitreous

$\frac{I_r}{I_o} = \frac{[Z_2 - Z_1]^2}{[Z_2 - Z_1]^2}$

$= \frac{[1.72 - 1.54]^2}{[1.72 + 1.54]^2}$ [1]

= 0.0030486

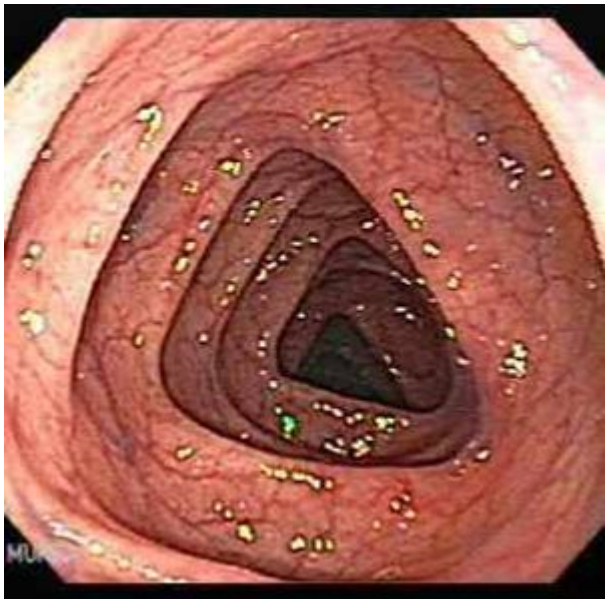
=0.3% reflection [1]

c) Justify the use of ultrasound to image an organ such as the eye. [3]

Students must make reference to previous result in (b) and mention that due to the small amount of reflection taking place at the boundary means the ultrasound signal has enough intensity to image the rest of the eye. [2]

Students can mention the safety of using ultrasound (non ionising). [1]

2.



The following image was taken during a colleenoscopy (sorry I meant to write colonoscopy ☺), in other words an examination of the colon or large intestine. Describe how optic fibres are used to produce an image such as the one shown. [3]

Students must make reference to coherent and incoherent bundles and each of their applications. [2]

Students must make reference to total internal reflection being used as a method of propagation of light through the fibres. [1]

3. Justify the use of a contrast agent such as a Barium meal when performing X ray examinations.

Barium meals are often used to image the intestines. The absorption of X rays by neighbouring tissues in this region is too similar to generate contrast. Hence a contrast agent is introduced to ensure that different tissues are absorbing X rays in very different amounts and thus creates contrast and a clear outline of the organ of interest.

[3]

4. Compare and contrast the use of PET and CT scans in medical diagnosis. [6]

Students must

- refer to the use of gamma rays in PET and X rays in CT scans.

- mention that both produce and subject the patient to ionising radiation.

- both relatively expensive procedures

- both not portable

- Students must mention structure for CT and function for PET.

- both often used together these days.

5. "An understanding of the nature of light and other forms of electromagnet radiation was crucial in the development of imaging technologies such as MRI, X rays and others."

Evaluate this statement. [6]

Student:	Mark Awarded
- Includes VJ - Gives at least 3 applications of the use of EMR in medical imaging eg. Computer screens, Radio waves in MRI, TIR in endoscopes. - Explains the importance of understanding EMR in the applications mentioned.	6
- Includes VJ - Gives at most 2 applications of the use of EMR in medical imaging eg. Computer screens, Radio waves in MRI. - Explains the importance of understanding EMR in the applications mentioned.	5
- Includes VJ - Gives at most 2 applications of the use of EMR in medical imaging eg. Computer screens, Radio waves in MRI. - Fails to explain the importance of understanding EMR in the applications mentioned.	4
- Includes VJ - Gives few examples of the application of EMR in medical imaging. - Fails to explain the importance of understanding EMR in the applications mentioned.	1-3

Multiple Choice Answer Sheet **Student number**……

	A	B	C	D
1	⊗	○	○	○
2	○	○	○	⊗
3	○	⊗	○	○
4	⊗	○	○	○
5	○	○	⊗	○
6	○	○	○	○
7	○	○	○	○
8	⊗	○	○	○
9	⊗	○	○	○
10	○	○	⊗	○
11	○	⊗	○	○
12	○	○	○	⊗
13	○	⊗	○	○
14	○	○	⊗	○
15	○	○	⊗	○
16	○	⊗	○	○
17	⊗	○	○	○
18	○	○	⊗	○
19	○	○	○	⊗
20	⊗	○	○	○