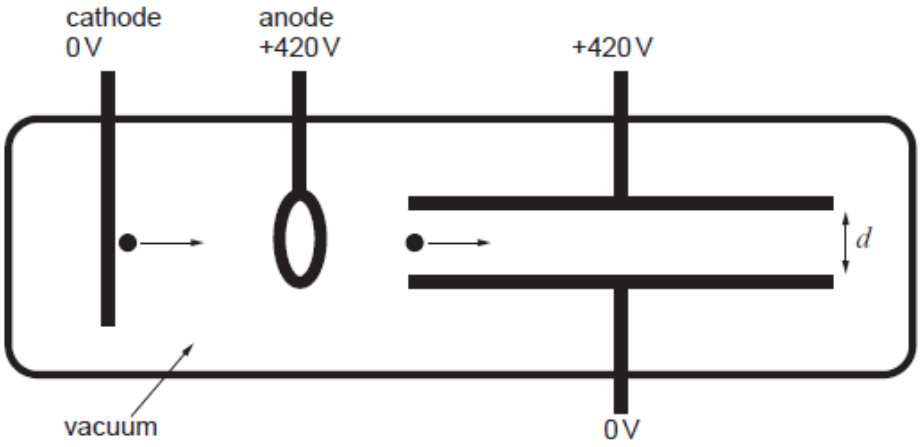
Physics

Question	Maximum Mark	Mark Awarded
#1	7	
#2	7	
#3	8	
#4	10	
#5	11	
#6	11	
#7	12	
#8	12	
#9	15	
#10	16	
Total	109	

#1

An electron is accelerated from rest by a pd of 420 V and then enters the uniform electric field between two parallel plates separated by a distance, d. These parallel plates also have a pd of 420 V across them and the electron enters halfway between the two plates.



(a) Show that, when the electron has travelled a distance, d, horizontally, it will have travelled a distance of $\frac{1}{4}d$ vertically (from the point where it enters the parallel plates). [5]

(b) Explain whether or not an oxygen ion with charge $-2e$ accelerated from rest in the above set-up instead of an electron would pass through the same point. [2]

Question taken from Eduqas examination paper 842103, November 2020

#2

2. *(a)* (i) Define the angular velocity, ω, for a body moving in a circle. [1]

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(ii) Two equations giving the acceleration of a body moving at constant speed in a circle are:

$$a = \frac{v^2}{r} \quad \text{and} \quad a = r\omega^2.$$

Show clearly that the equations are equivalent. [2]

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(b) A moon called *Deimos* orbits Mars in a circular path of radius 23 500 km. Astronomers have calculated the mass of Deimos to be 1.48×10^{15} kg, and the force exerted on it by Mars to be 1.15×10^{14} N.

(i) Calculate the speed of Deimos around Mars. [2]

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(ii) Explain whether or not a moon of twice the mass of Deimos, but in a circular orbit of the same radius about Mars, would have the same speed as Deimos. [2]

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Question taken from Eduqas examination paper 842101, June 2018

#3

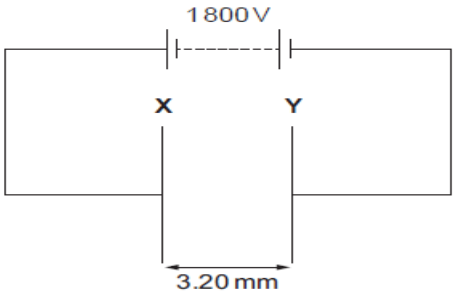
(a) A sphere made of caesium is placed in space and illuminated by ultraviolet radiation of photon energy 10.3 eV. The work function of caesium is 2.1 eV. Explain in clear steps, using Einstein's photoelectric equation (and other physics), why the maximum potential attainable by the caesium sphere is +8.2 V. [5]

(b) Hence, calculate the maximum electric field strength around the caesium sphere given that its radius is 6.5 cm. [3]

Question taken from Eduqas examination paper 842103, November 2020

#4

A scientist investigating electric fields places two parallel plates **X** and **Y** a distance 3.20 mm apart and connects them to a high voltage supply as shown. There is a vacuum between the plates.



(a) **Sketch the electric field pattern** between the plates indicating clearly the direction of the field. [1]

(b) Electrons are accelerated from plate **Y** to plate **X**. Calculate:

(i) the force on an electron; [2]

(ii) the gain in kinetic energy of an electron as it travels from **Y** to **X**; [2]

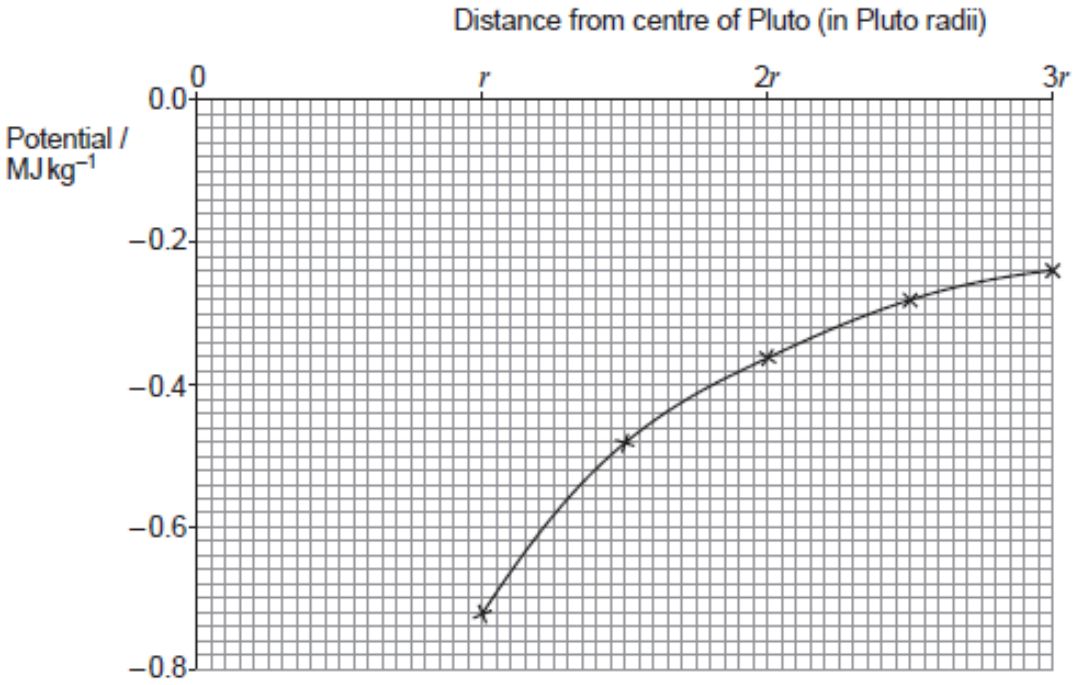
(iii) the time it takes for an electron to travel from **Y** to **X**. Assume the electron starts from rest at plate **Y**. [3]

(c) The separation between the plates is now halved but the pd is unchanged. The scientist believes that the gain in kinetic energy of an electron travelling (from rest) from **Y** to **X** will be unchanged. Verify this claim. [2]

Question taken from Eduqas examination paper 842102, June 2017

#5

6. The variation in gravitational potential near Pluto is shown by the graph.



(a) Assuming that the potential at the surface is correct, confirm that the potential at $3r$ is plotted correctly. [2]

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(b) (i) Calculate the gravitational potential energy of a spacecraft of mass 600 kg at rest on the surface. [2]

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(ii) 'Escape velocity' is defined as the minimum velocity required for a body to escape from the gravitational influence of a massive body. Calculate the 'escape velocity' of the spacecraft. [3]

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(c) The radius of Pluto is 1.18×10^6 m and the gravitational field strength at the surface is $0.62\,\text{N kg}^{-1}$. Using this information and by **drawing a suitable tangent** show that the gravitational field strength at $2r$ agrees with the theoretical value given by:

$$g \propto \frac{1}{r^2}$$ [4]

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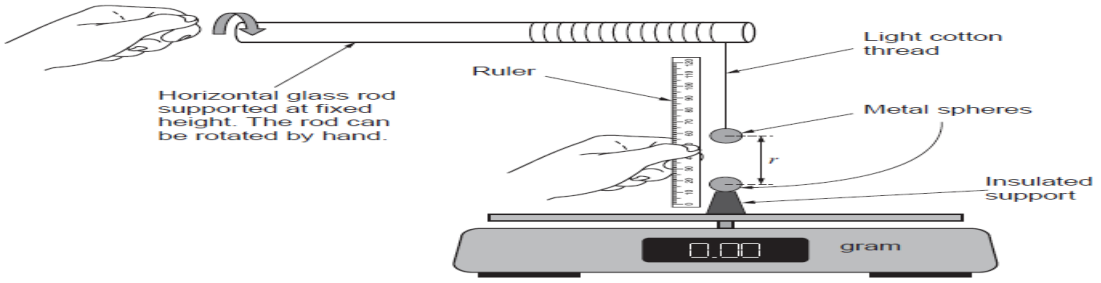
Question taken from Eduqas examination paper 842102, June 2019

#6

Two students, Ben and Sarah, use the following apparatus to investigate the 'inverse square' nature of Coulomb's law.



The **same** negative charge is placed on both spheres. The distance, r, between the centres of the spheres is varied and the reading on the top pan balance is noted. Sarah and Ben disagree on the best method to measure r.

Ben favours using a ruler with a resolution of 1 mm to measure it directly.

Sarah suggests measuring the diameter of the glass rod with Vernier calipers, with a resolution of 0.01 mm, to determine the circumference of the rod. The rod can then be rotated by hand, with each complete rotation corresponding to the calculated circumference.

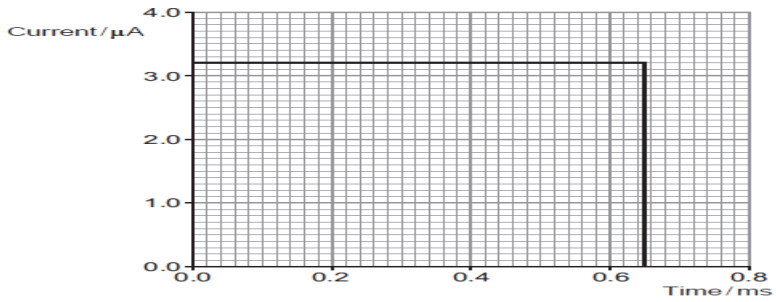
(a) (i) State an advantage and a disadvantage of each method. [4]

(ii) Suggest an improvement to **one** of the techniques which would increase the accuracy of measuring r. [1]

(b) When r = 20 mm, the reading on the top pan balance is 0.01 gram.

(i) Show that the value of Q_1Q_2, the product of the charges on the spheres, when r = 20 mm is approximately 4.4×10^{-18} C^2. [3]

(ii) One of the spheres is now discharged. The graph shows how the discharge current varies with time.



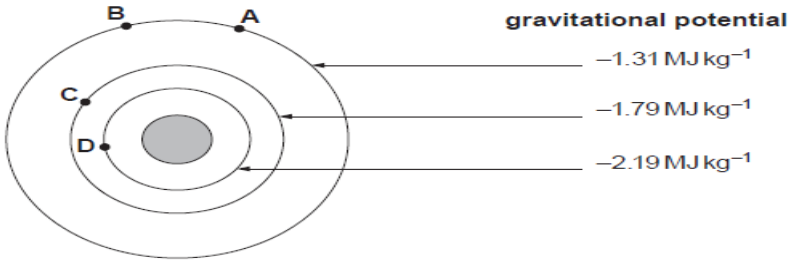
Show that the values given on the graph are consistent with the product Q_1Q_2 in *(b)*(i). [2]

(iii) Hence, estimate the number of electrons on **one** sphere when the reading on the balance is 0.01 gram and r = 20 mm. [1]

Question taken from Eduqas examination paper 842102, June 2017

#7

(a) The diagram shows a series of equipotentials around the Moon showing values of the gravitational potential. **A**, **B**, **C** and **D** are four points on the equipotentials.



(i) Explain why the potentials have negative signs. [2]

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(ii) A spacecraft of mass 300 kg orbits the Moon. Determine, showing your reasoning, the changes in the gravitational potential energy of the spacecraft when it moves from:

I. **A** to **B**; [2]

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II. **B** to **C**. [2]

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(iii) The spacecraft is now directed from point **D** towards the Moon's surface with an initial speed of $0\,m\,s^{-1}$ in this direction. Calculate the speed at which the spacecraft impacts with the Moon's surface.
[Mass of Moon = 7.35×10^{22} kg. Radius of Moon = 1 740 km] [4]

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(b) Many space agencies have deliberately crashed their spacecraft on to the Moon for scientific purposes. The Lunar Crater Observation and Sensing Satellite (LCROSS) is one example which, along with its companion rocket, Centaur, impacted with the Moon in 2009. The following extract is taken from the space agency press release about the mission:

The primary goal of LCROSS is to measure the concentration of water (ice) in permanently shadowed lunar soil. When the Centaur, weighing up to 2 366 kg hits the floor of a permanently shadowed crater there will be an initial flash followed by the creation of a debris plume. If water is present on the floor of the crater, it will be thrown skyward. The LCROSS spacecraft, following four minutes behind, will collect and transmit data back to Mission Control about the debris plume before itself impacting the surface. A possible result of both of the impacts is the creation of a temporary thin atmosphere of hydroxyl ions. This resulting atmosphere could be detectable using telescopes on Earth.

[NASA LCROSS press kit June 2009]

Discuss the benefits and cost to society of such missions. [2]

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Question taken from Eduqas examination paper 842102, June 2017

#8

8. *(a)* State **one** similarity and **one** difference between gravitational and electric fields. [2]

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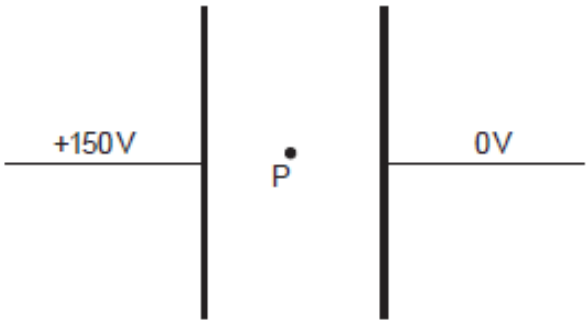
(b) Two parallel vertical metal plates are placed 5.0 cm apart in a vacuum as shown. A pd of 150 V is placed across the plates and a small sphere of mass 9.6×10^{-15} kg carrying a charge of -2.4×10^{-17} C is placed at point P. A side-on view of the arrangement is shown.



(i) Show that the two forces acting on the sphere are approximately 9×10^{-14} N vertically and 7×10^{-14} N horizontally. [3]

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(ii) Draw, in the space below, a free body diagram for the sphere, showing the magnitude and direction of the two forces acting on it. Determine the direction with which the sphere will move away from P and include this on your diagram. [3]

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(c) Calculate the time taken for the sphere to travel a distance of 2.0 cm. [4]

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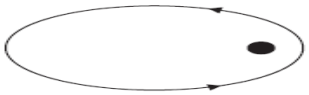
Question taken from Eduqas examination paper 842102, June 2019

#9

(a) The diagram shows the elliptical orbit of a planet around a star. Use the diagram (by adding to it) to explain Kepler's second law of planetary motion. [2]



(b) Starting with Newton's law of gravitation, show that for a circular orbit, the period of orbit, T, of a planet around a star is related to its distance, r, from the centre of the star by the relationship $T^2 \propto r^3$. [Assume the mass of the planet is much less than the mass of the star.] [3]

(c) Mars has two small moons, Phobos and Deimos. The diagram shows their orbital paths around Mars.

(i) Phobos has an orbital period of 7.7 hours and the radius of its orbit is 9400 km. Show that the mass of Mars is approximately 6.4×10^{23} kg. [3]

(ii) It is proposed to send a space-probe to study Phobos and Deimos. The first part of the mission will be to place the probe in orbit around Phobos.

I. Show that the gravitational potential due to Mars at the Phobos orbit is approximately $-4.5\,\text{MJ kg}^{-1}$. [2]

II. The second part of the mission involves manoeuvring the space-probe into a higher orbit to enable it to study Deimos. However, on the journey to Mars the probe used more fuel than was expected. Scientists are now unsure as to whether or not the probe has enough fuel to enable it to reach the orbit of Deimos. The following information is available:

Energy available per kg of space-probe: $4.4\,\text{MJ kg}^{-1}$
Efficiency of fuel-burn process: 60 %
Distance of Deimos from centre of Mars: 23 500 km

Assuming the mass of the fuel is very small compared to the mass of the probe itself, and ignoring the gravitational effects of both moons, determine whether or not the scientists should attempt the manoeuvre. [4]

(iii) Explain why it is not possible to use the equation $\Delta E_p = mg\Delta h$ when determining the change in the gravitational potential energy of the probe as it moves between these orbits. [1]

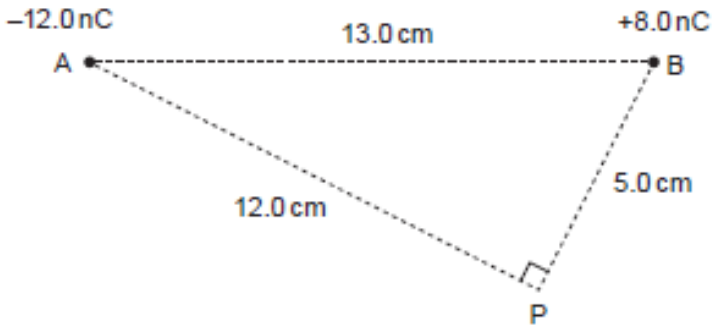
Question taken from Eduqas examination paper 842102, November 2020

#10

7. *(a)* Complete the following table: [3]

Quantity	Definition	Vector or Scalar
Electric field strength, E	.....	.....
Electric potential, V	.....	.....

(b) Point charges of –12.0 nC and +8.0 nC are placed at A and B, 13.0 cm apart as shown. P is a point in space which is 12.0 cm from A and 5.0 cm from B.



(i) Draw on the diagram **two** arrows to show the directions of the field strength at P due to each charge. [1]

(ii) Hence draw on the diagram **one** arrow to represent the direction of the resultant field strength at P. **Label this arrow R.** [1]

(iii) Calculate the **magnitude and direction** of the electric field strength at P. [4]

(c) (i) Show that the potential at P is + 540 V. [2]

(ii) Calculate the gain in kinetic energy in joules of an electron as it moves from infinity to P. [2]

(d) Without calculation, explain how the de Broglie wavelength of the electron changes as it moves towards P. [3]

Question taken from Eduqas examination paper 842102, June 2018