Q1. Which of the following statements about Newton's law of gravitation is correct?

Newton's gravitational law explains

    A the origin of gravitational forces. ☐

    B why a falling satellite burns up when it enters the Earth's atmosphere. ☐

    C why projectiles maintain a uniform horizontal speed. ☐

    D how various factors affect the gravitational force between two particles. ☐

(Total 1 mark)

Q2. A spacecraft of mass m is at the mid-point between the centres of a planet of mass M_1 and its moon of mass M_2. If the distance between the spacecraft and the centre of the planet is d, what is the magnitude of the resultant gravitational force on the spacecraft?

A $\dfrac{Gm(M_1 - M_2)}{d}$

B $\dfrac{Gm(M_1 + M_2)}{d^2}$

C $\dfrac{Gm(M_1 - M_2)}{d^2}$

D $\dfrac{Gm(M_1 + M_2)}{d}$

(Total 1 mark)

Q3. (a)   (i)   Define gravitational field strength and state whether it is a scalar or vector quantity.

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(2)

(ii)   A mass m is at a height h above the surface of a planet of mass M and radius R.
The gravitational field strength at height h is g. By considering the gravitational force acting on mass m, derive an equation from Newton's law of gravitation to express g in terms of M, R, h and the gravitational constant G.

(2)

(b)   (i)   A satellite of mass 2520 kg is at a height of 1.39×10^7 m above the surface of the Earth. Calculate the gravitational force of the Earth attracting the satellite. Give your answer to an appropriate number of significant figures.

force attracting satellite .... N

(3)

(ii)   The satellite in part (i) is in a circular polar orbit. Show that the satellite would travel around the Earth three times every 24 hours.

(5)

(c)   State and explain **one** possible use for the satellite travelling in the orbit in part (ii).

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(2)
(Total 14 marks)

Q4. When a space shuttle is in a low orbit around the Earth it experiences gravitational forces F_E due to the Earth, F_M due to the Moon and F_S due to the Sun. Which one of the following correctly shows how the magnitudes of these forces are related to each other?

mass of Sun = 1.99×10^{30} kg
mass of Moon = 7.35×10^{22} kg
mean distance from Earth to Sun = 1.50×10^{11} m
mean distance from Earth to Moon = 3.84×10^8 m
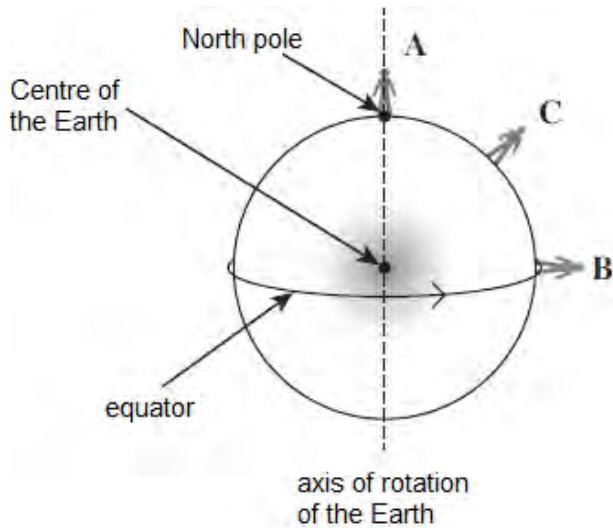
A $F_E > F_S > F_M$

B $F_S > F_E > F_M$

C $F_E > F_M > F_S$
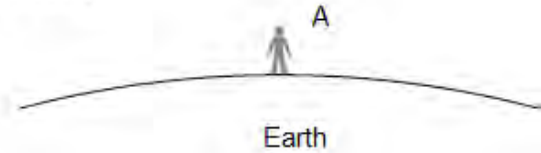
D $F_M > F_E > F_S$

(Total 1 mark)

Q5.Figure 1 shows (not to scale) three students, each of mass 50.0 kg, standing at different points on the Earth's surface. Student **A** is standing at the North Pole and student **B** is standing at the equator.

Figure 1   **Figure 2**

The radius of the Earth is 6370 km.
The mass of the Earth is 5.98×10^{22} kg.

In this question assume that the Earth is a perfect sphere.

(a) (i) Use Newton's gravitational law to calculate the gravitational force exerted by the Earth on a student.

force .... N

(3)

(ii) **Figure 2** shows a closer view of student **A**.
Draw, on **Figure 2**, vector arrows that represent the forces acting on student **A**.

(2)

(b) (i) Show that the linear speed of student **B** due to the rotation of the Earth is about 460 ms^{-1}.

(ii)   Calculate the magnitude of the centripetal force required so that student **B** moves with the Earth at the rotational speed of 460 ms^{-1}.

magnitude of the force .... N

(2)

(iii)   Show, on **Figure 1**, an arrow showing the direction of the centripetal force acting on student **C**.

(1)

(c)   Student **B** stands on a bathroom scale calibrated to measure weight in newton (N). If the Earth were not rotating, the weight recorded would be equal to the force calculated in part (a)(i).

State and explain how the rotation of the Earth affects the reading on the bathroom scale for student **B**.

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(3)
(Total 14 marks)

Q6. Which one of the following gives a correct unit for $\left(\dfrac{g^2}{G}\right)$?

    A $N\,m^{-2}$

    B $N\,kg^{-1}$

    C $N\,m$

    D N

(Total 1 mark)

Q7.   An object on the surface of a planet of radius R and mass M has weight W.
What would be the weight of the same object when on the surface of a planet of radius $2R$ and mass $2M$?

    A $\dfrac{W}{4}$

    B $\dfrac{W}{2}$

    C W

    D $2W$

(Total 1 mark)

Q8.   Which one of the following statements about Newton's law of gravitation is correct?

Newton's law of gravitation explains

    A   the origin of gravitational forces.
    B   why a falling satellite burns up when it enters the Earth's atmosphere.
    C   why projectiles maintain a uniform horizontal speed.
    D   how various factors affect the gravitational force between two particles.

(Total 1 mark)

Q9. If an electron and proton are separated by a distance of 5×10^{-11} m, what is the approximate gravitational force of attraction between them?

A 2×10^{-57} N

B 3×10^{-47} N

C 4×10^{-47} N

D 5×10^{-37} N

(Total 1 mark)

Q10. Masses of M and $2M$ exert a gravitational force F on each other when the distance between their centres is r. What is the gravitational force between masses of $2M$ and $4M$ when the distance between their centres is $4r$?

A   0.25 F

B   0.50 F

C   0.75 F

D   1.00 F

(Total 1 mark)

Q11. At the surface of the Earth the gravitational field strength is g, and the gravitational potential is V. The radius of the Earth is R. An object, whose weight on the surface of the Earth is W, is moved to a height $3R$ above the surface. Which line, **A** to **D**, in the table gives the weight of the object and the gravitational potential at this height?

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	weight	gravitational potential
A	$\dfrac{W}{16}$	$\dfrac{V}{4}$
B	$\dfrac{W}{4}$	$\dfrac{V}{3}$
C	$\dfrac{W}{4}$	$\dfrac{V}{4}$
D	$\dfrac{W}{16}$	$\dfrac{V}{3}$

(Total 1 mark)

Q12.　　　The gravitational force between two uniform spheres is 3.1×10^{-9} N when the distance between their centres is 150 mm. If the mass of one sphere is 2.5 kg, what is the mass of the other?

A　　0.043 kg

B　　0.42 kg

C　　2.8 kg

D　　4.1 kg

(Total 1 mark)

Q13.　　　Two protons are 1.0×10^{-14} m apart. Approximately how many times is the electrostatic force between them greater than the gravitational force between them? (Use the Data and Formulae booklet)

A　　10^{23}

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B 10^{30}

C 10^{36}

D 10^{42}

(Total 1 mark)

Q14.   A projectile moves in a gravitational field. Which one of the following is a correct statement about the gravitational force acting on the projectile?

A   The force is in the direction of the field.

B   The force is in the opposite direction to that of the field.

C   The force is at right angles to the field.

D   The force is at an angle between 0° and 90° to the field.

(Total 1 mark)