Name: ____________________________ (   ) **CT Group: 24S0** _______

RAFFLES INSTITUTION

2023 YEAR 5 TERM 3 COMMON TEST

4 July 2023

H2 PHYSICS

Section B

INSTRUCTIONS TO CANDIDATES

Write your name, index number and CT Group.

Write your answers to Section B in the spaces provided on the question paper.

You are advised to write all your workings and answers clearly. Marks may be deducted for unclear workings.

For Examiner's Use		
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Deductions		
Total		/ 85

This document consists of **19** printed pages.

Section B (71 marks)

1 The resistance R of a wire is related to its length L and cross-sectional area A by the equation

$$R = \rho \frac{L}{A}$$

where ρ is the resistivity of the material that the wire is made of.

To determine the resistivity of the material of a wire, a student needs to first determine the resistance of the wire. He sets up an electrical circuit to measure the potential difference V across the wire and the current I through the wire and calculates the resistance R of the wire using $R = \frac{V}{I}$. He also measured the length L and the diameter d of the wire using a meter rule and a micrometer screw gauge, respectively.

(a) While measuring the diameter, the student failed to notice that the micrometer screw gauge reading is not zero when it is fully closed.

State and explain whether this introduces random error or systematic error to the measurements of the diameter.

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.... [2]

(b) The student eventually realised his mistake and accounted for the zero error in his measurements. The average values of all quantities, with their uncertainties, are shown in Fig. 1.1.

V / V	I / A	d / mm	L / cm
1.50 ± 0.01	0.32 ± 0.01	0.23 ± 0.01	40.0 ± 0.1

Fig. 1.1

(i) Calculate the value of ρ.

ρ = ... Ω m [3]

(ii) Calculate the uncertainty in ρ.

uncertainty in ρ = ... Ω m [2]

(iii) Express the value of ρ together with its uncertainty to the appropriate number of significant figures.

ρ = ... $\pm$ .... Ω m [1]

(c) The true value for ρ is 4.4×10^{-7} Ω m.
Use your answer in **(b)(iii)** to distinguish between *accuracy* and *precision*.

accuracy ....

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precision ....

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.... [2]

2 **(a)** A fighter jet approaches a stationary tank at a speed of 220 m s^{-1} and at an angle of $15°$ below the horizontal as shown in Fig. 2.1. A bomb is released from the fighter jet when it is at a height of 800 m above the ground and 1500 m away from the tank.

Assume that air resistance is negligible.

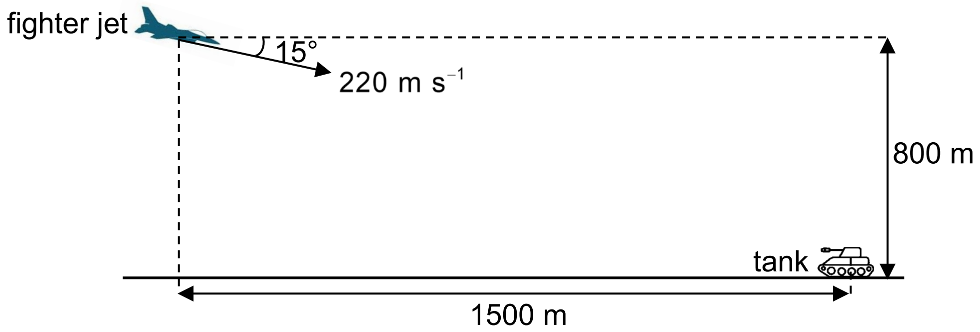

Fig. 2.1

(i) After the bomb falls through a vertical distance of 800 m,

1. calculate the time elapsed from when it was released,

time = ... s [2]

2. determine the magnitude and direction of its velocity.

magnitude = ... m s^{-1}

direction = ... [3]

(ii) Explain, with appropriate calculations, whether the bomb will hit the tank.

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.... [2]

(iii) On Fig. 2.2, sketch the variation with time *t* of the vertical displacement s_y of the bomb from the point of release for the duration in **(a)(i)1.** Take downwards direction as positive.

Fig. 2.2

[1]

(b) Two projectiles are launched simultaneously from the same point to hit targets A and B. Fig. 2.3 shows the path of each projectile. Both projectiles reach the same maximum height before hitting their respective targets A and B.

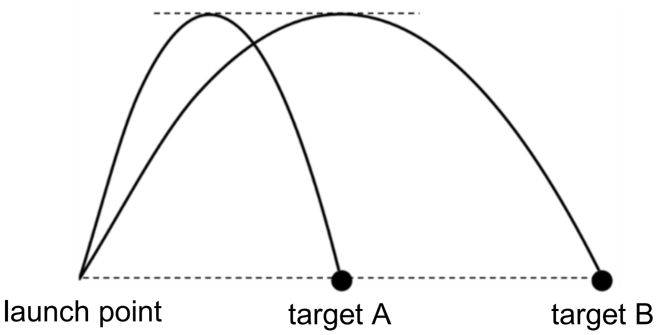

Fig. 2.3

Explain whether the projectiles hit their respective targets at the same time.

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.... [2]

3 **(a)** Distinguish between the *mass* and *weight* of a body.

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.... [2]

(b) Explain why a passenger sometimes feels lighter in a lift.

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.... [2]

(c) Fig. 3.1 shows a pile driver of mass 800 kg which is released from rest and falls vertically through a height of 5.0 m before striking a pile of mass 200 kg. The pile then penetrates vertically into the soil. The average soil resistance on the pile is 450 kN.

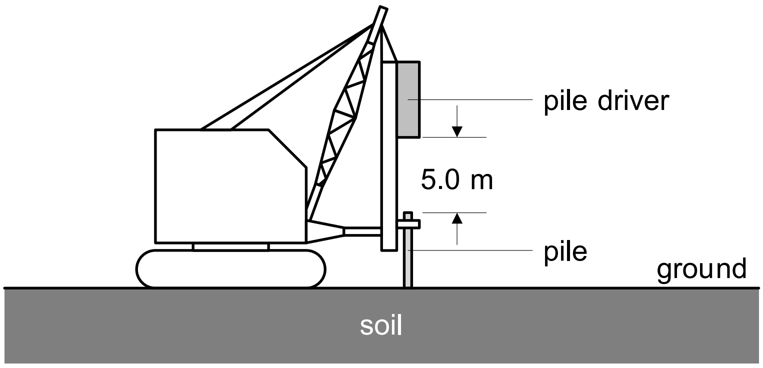

Fig. 3.1

Assuming that air resistance is negligible and that the pile driver moves together with the pile after striking it, calculate

(i) the velocity v_1 of the pile driver just before impact with the pile,

v_1 = ... m s^{-1} [2]

(ii) the velocity v_2 of the pile just after impact,

v_2 = ... m s^{-1} [2]

(iii) the penetration depth of the pile into the soil.

penetration depth = ... m [3]

4 A street sign is in the shape of an equilateral triangle of side length L and mass 2.5 kg. Its centre of gravity, O, is at the centroid of the triangle.

The centroid of the equilateral triangle is the point of intersection of the perpendicular bisectors of the sides of the triangle and is equidistant from each of the vertices A, B and C as shown in Fig. 4.1.

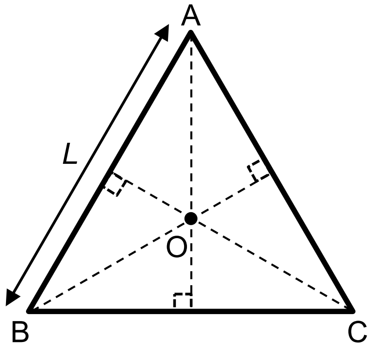

Fig. 4.1

(a) The street sign is hung from the ceiling by two vertical light cables attached to A and C such that side AB is vertical, as shown in Fig. 4.2.

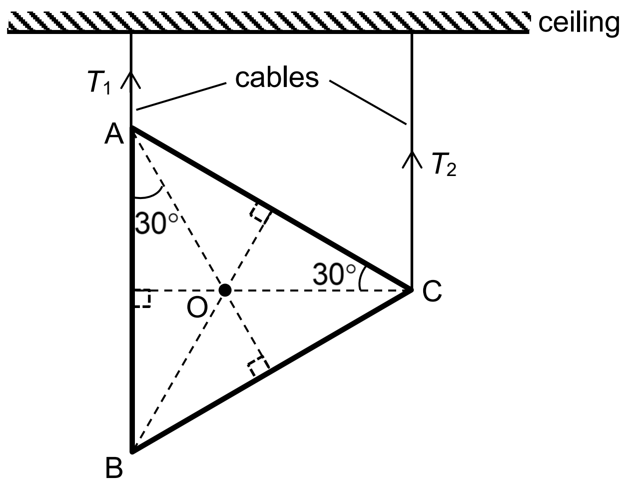

Fig. 4.2

(i) State what is meant by *centre of gravity*.

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....

.... [1]

(ii) State the principle of moments.

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.... [1]

(iii) Determine the tensions T_1 and T_2 in the two cables. Show your working clearly.

T_1 = ... N

T_2 = ... N [4]

(iv) To reduce the tension in the cable attached to vertex A, with the street sign hung in the same orientation as before, the cables could be attached in a slanted manner as shown in Fig. 4.3.

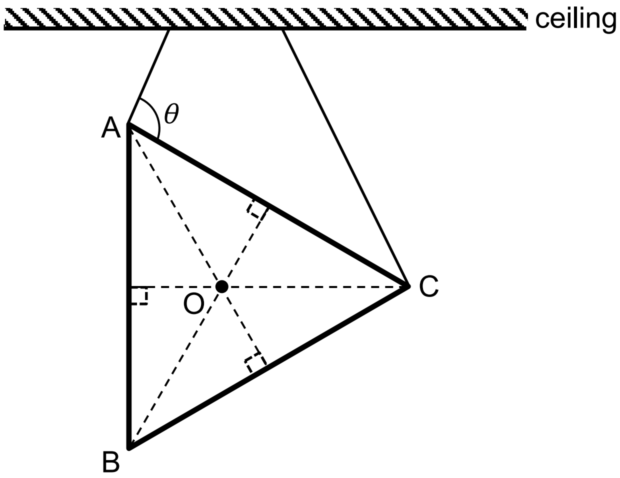

Fig. 4.3

The angle between the cable attached to vertex A and side AC is θ.

By considering moments about vertex C, state the value of θ so that the tension in the cable attached to vertex A is the smallest possible. Explain your answer.

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.... [2]

(b) To wash the street sign, it is dipped into a large tank of water with vertex A pointing downwards as shown in Fig. 4.4.

The height of the water level in the tank is H. When the street sign is dipped into the large tank of water, it can be assumed that the change in the water level is negligible.

The thickness of the street sign is t, and the density of water is ρ.

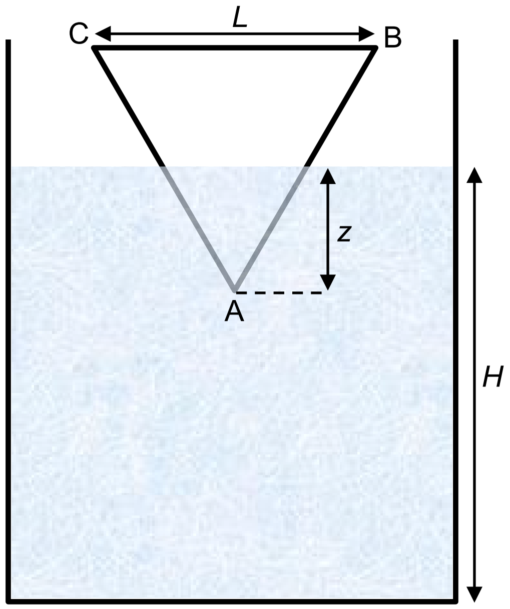

Fig. 4.4

(i) Show that the upthrust U experienced by the street sign when vertex A is a distance z below the surface of the water is given by the expression

$$U = 0.577\rho t g z^2$$

where g is the acceleration of free fall.

[2]

(ii) The street sign is dipped into the tank of water until it is fully submerged. It is then dipped further into the tank of water until vertex A touches the bottom of the tank, such that z is equal to H.

On Fig. 4.5, sketch a graph to show the variation with z of U from $z = 0$ to $z = H$.

Include any appropriate expressions on the axes.

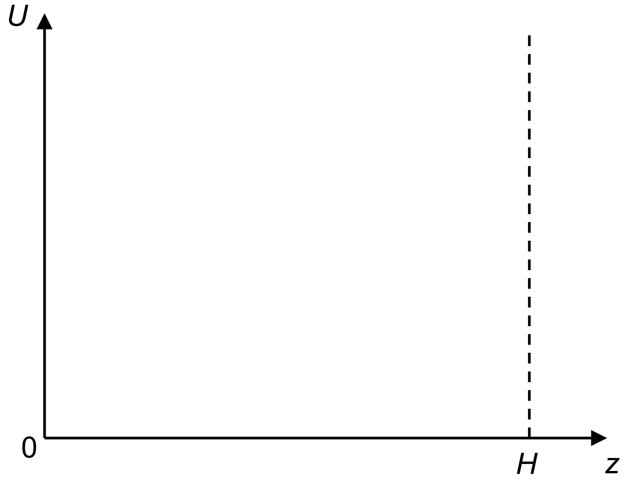

Fig. 4.5

[3]

5 A block of mass 200 g is released from rest and slides 0.40 m down a straight, frictionless slope before colliding with a spring as shown in Fig. 5.1. The block compresses the spring and comes to a stop momentarily.

The slope is at an angle of 30° to the horizontal and the spring has a force constant of 250 N m^{-1}.

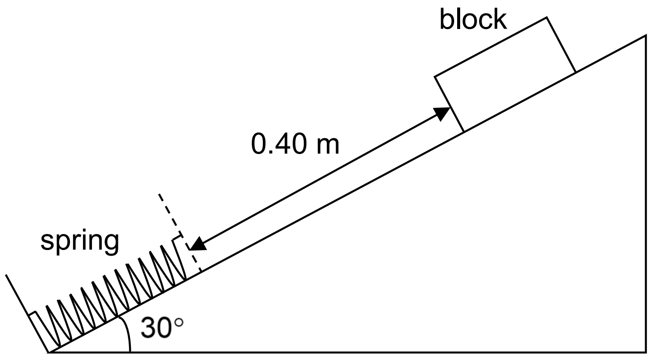

Fig 5.1

(a) Calculate the maximum compression of the spring.

maximum compression = ... m [2]

(b) Calculate the maximum kinetic energy of the block.

maximum kinetic energy = ... J [3]

(c) From the time the block was released until it first comes to a momentary stop, on Fig. 5.2, sketch the variation with displacement *d* of the block along the slope of the

(i) gravitational potential energy of the block where gravitational potential energy is zero at the position the block stops momentarily,

(ii) elastic potential energy of the spring,

(iii) kinetic energy of the block.

Label the graphs with 'GPE', 'EPE' and 'KE' respectively.
No numerical values are required.

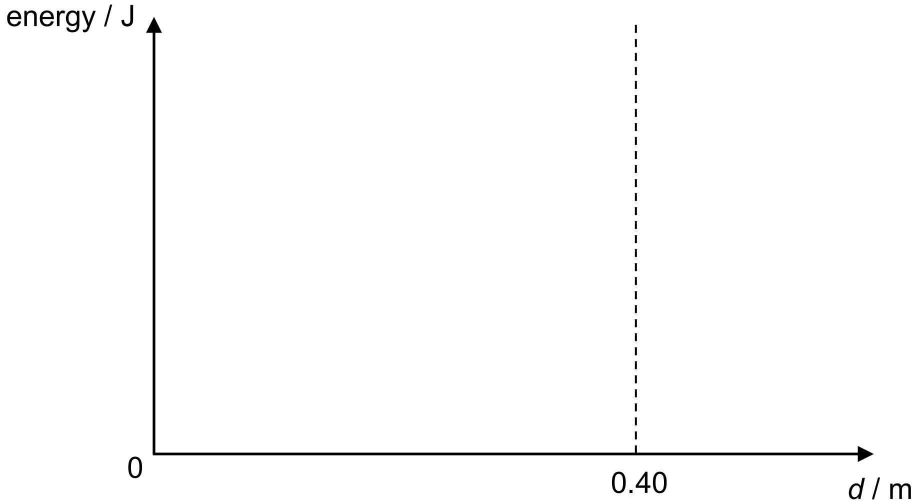

Fig. 5.2

[4]

6 A simple amusement park ride consists of a light cage connected to a light rod. The rod is pivoted at one end and rotates freely about the pivot.

At the start of one ride, a person sits in the cage and several strong men push the cage while it is hanging at rest such that the person and the cage move in a vertical circle of radius 2.5 m. The person and the cage have the same velocity at all times.

Fig. 6.1 shows the cage when it is at point A, the lowest point of the circle, and point B, the highest point of the circle. When the cage is at point B, the person in it is upside down.

Ignore all resistive forces throughout the ride.

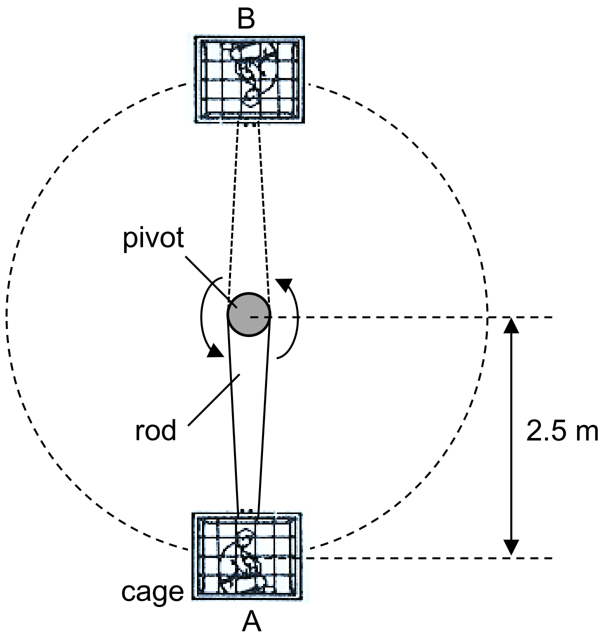

Fig. 6.1

(a) Determine the minimum speed the person must have at point B such that the person does not fall off from the floor of the cage. Explain your working.

speed = ... m s^{-1} [3]

(b) Calculate the minimum speed of the person at point A.

speed = ... m s^{-1} [2]

(c) At which point, A or B, does the person feel heavier? Explain your answer.

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.... [2]

7 **(a)** The gravitational potential ϕ at a distance r from an isolated point mass M is given by the expression

$$\phi = -\frac{GM}{r}$$

where G is the gravitational constant and ϕ is taken to be zero at infinity.

Explain why gravitational potential is negative.

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.... [2]

(b) Fig. 7.1 shows the variation of the gravitational potential ϕ between the surface of the Earth and the surface of the Moon with distance from the centre of the Earth along the line joining their centres. Point P is the point where gravitational potential is maximum.

The masses of the Earth and the Moon are 5.98×10^{24} kg and 7.35×10^{22} kg respectively, and their centres are 3.84×10^{8} m apart.

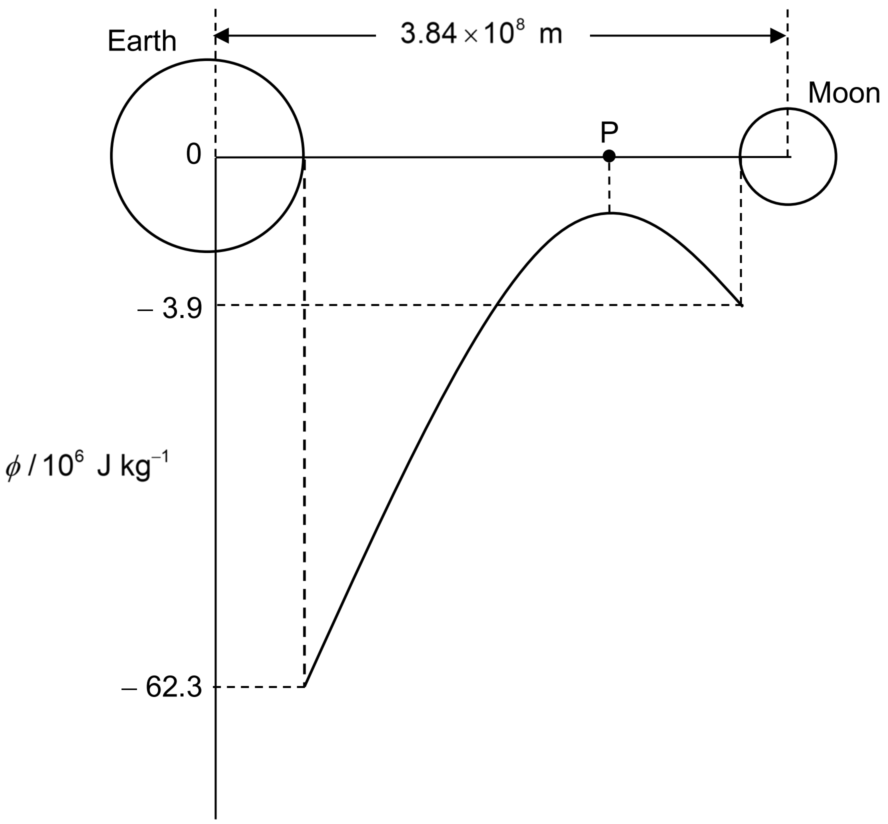

Fig. 7.1

(i) Show that the distance to point P from the centre of the Earth is 3.46×10^{8} m.

[2]

(ii) Calculate the gravitational potential ϕ_P at point P.

ϕ_P = ... J kg^{-1} [2]

(iii) A rock on the Earth was found to have a composition identical to that of lunar granite. It is believed that this rock is debris that was projected from the surface of the Moon due to a volcanic eruption on the Moon which then landed on the Earth.

Assume that the rock was projected from the Moon directly to the Earth and ignore all resistive forces.

1. Using data from Fig. 7.1, determine the theoretical minimum speed with which the rock would have hit the Earth.

speed = ... m s^{-1} [2]

2. Suggest why, if the rock was projected from the Earth directly to the Moon, the theoretical minimum speed upon reaching the Moon is different from that found in **(b)(iii)1**.

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.... [2]

3. On Fig. 7.2, sketch the variation of the gravitational force F on the rock between the surface of the Earth and the surface of the Moon with distance from the centre of the Earth along the line joining their centres.

Indicate clearly point P on your sketch. No numerical values are required.

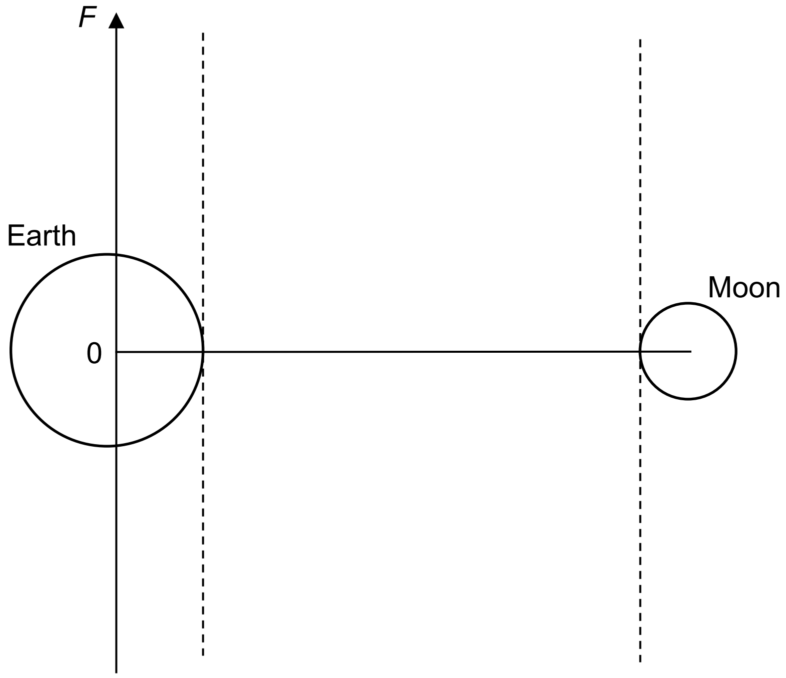

Fig. 7.2

[1]

END OF SECTION B