Section Two: Problem-solving 50% (81 Marks)

This section has **six (6)** questions. You must answer **all** questions. Write your answers in the space provided.

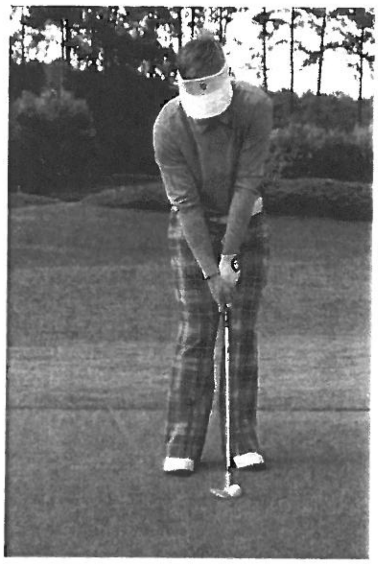
Spare pages are included at the end of this booklet. They can be used for planning your responses and/or as additional space if required to continue an answer.

- Planning: If you use the spare pages for planning, indicate this clearly at the top of the page.
- Continuing an answer: If you need to use the space to continue an answer, indicate in the original answer space where the answer is continued, i.e. give the page number. Fill in the number of the question(s) that you are continuing to answer at the top of the page.

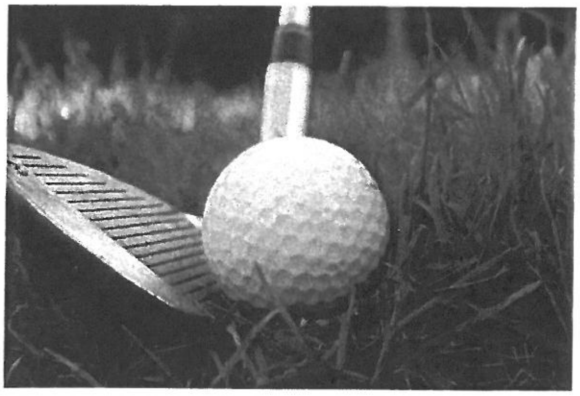
Suggested working time for this section is 90 minutes.

Question 14: (16 marks)

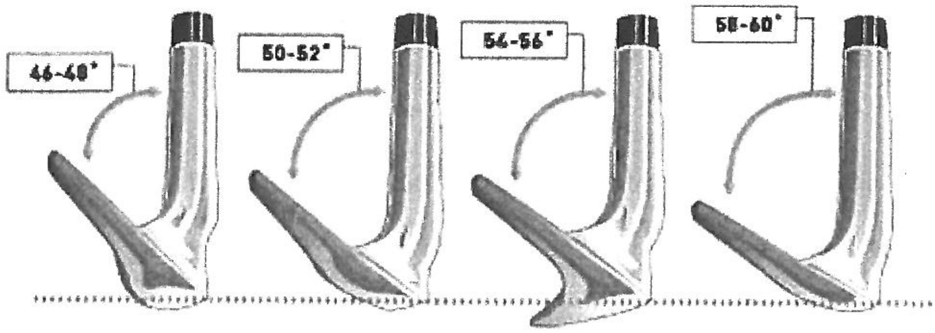
Chipping



Chipping is a technique used by golfers to hit golf ball accurately over short distances. The club used when chipping is called a wedge. It is designed so that when the ball is correctly hit the ball does not roll when it arrives at its destination, the green. To do this the club face is lofted. This means that the club face is inclined to the vertical as shown in the diagram.



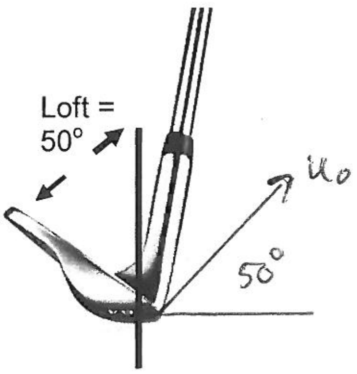
Different wedges have different uses and different loft angles. The most common wedges have loft angles of around 46 to 60°. The first of the wedges shown below shows the most common of wedges known as pitching wedges with loft angles between 46 and 48° that are designed to hit a golf ball 90 to 100 metres.

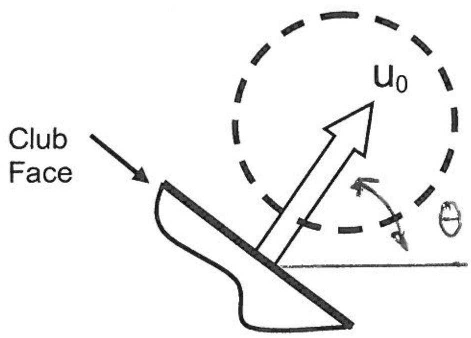


Question 14: (contd)

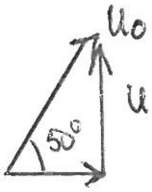
The second wedge is called a gap wedge pitching a golf ball 60 to 90 metres. The third wedge is a sand wedge designed to loft a golf ball out of a sand trap or bunker. The fourth wedge is called a lob wedge which is designed to hit the golf ball extremely high into the air over short distances, dropping the ball softly on the green with little or no roll.

The initial velocity of the ball is denoted as u_o. It is assumed that when hit the ball leaves the surface of the club at right angles to its face.





a) Write expressions giving the horizontal and vertical components of the golf ball's initial velocity u_o. (2 marks)



$u_v = u_o \sin 50^\circ$

$u_x = u_o \cos 50^\circ$

b) If you were given the value of u_0, explain how you would calculate each of the following given appropriate equations.

(i) the horizontal distance travelled by the golf ball in time *t*. (2 marks)

$s_x = u_x t + \frac{1}{2} a_x t^2$ $\quad a_x = 0$ (no air-resista

$\underline{S_x = u_0 \cos 50^\circ \times t}$

(ii) the height of the ball at any time *t*. (2 marks)

$s_x = u_x t + \frac{1}{2} g t^2$

$\underline{\underline{= u_0 \sin 50\ t + \frac{1}{2} g t^2}}$

Question 14: (contd)

d) Using your knowledge of physics explain why the pitching wedge has the greatest range. (2 marks)

Greatest range occurs at launch angle of 45°.

Pitching wedge has loft of 46 – 48° – closest to 45°.

c) Which wedge would you use to approach a hole 100 m away? What is its loft angle? (2 marks)

Pitching wedge. 46 – 48°

d) With the help of appropriate equations with what **speed** would you hit the ball with the wedge chosen in part c) above and what **time** would the ball be in the air? (4 marks)

If +ve up

Note $g = -ve$

$S_H = u_0 \cos 45° \times t$

$100 = u_0 \times 0.7071 \times t$ — equation 1.

$S_V = u_0 \sin 45° t + \frac{1}{2} \times -9.8 t^2$

$0 = \underline{u_0 \times 0.7071 t} + -4.9t^2$ (2)

substitute equn 1 in here

$4.9t^2 = 100$

$t = \sqrt{\frac{100}{4.9}} = \underline{\underline{4.51 \text{ sec}}}$ (1)

$u_0 = \frac{100}{0.7071 t} = \underline{\underline{31.3 \text{ ms}^{-1}}}$ (1)

e) What **two** assumptions did you use in your calculation in part d) above? (2 marks)

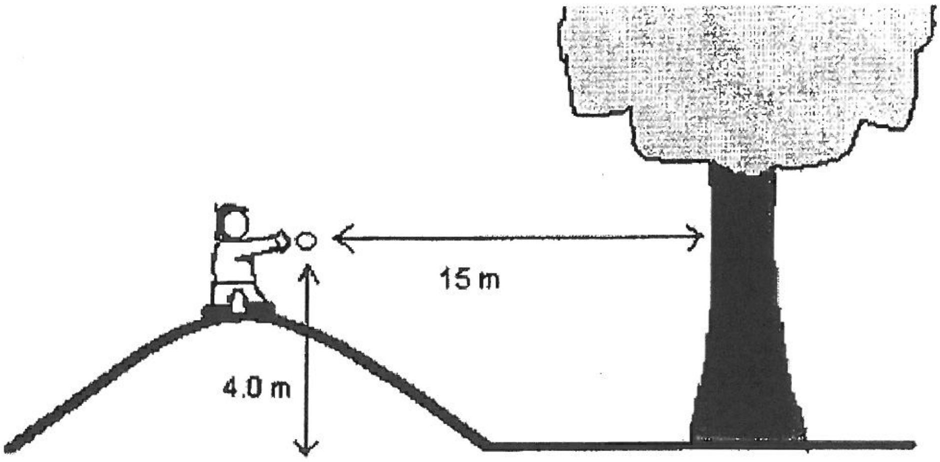
Air resistance is zero.

Wedge loft angle = 45°.

ground was flat.

Question 15: (11 marks)

A child standing on a small hill throws a snowball horizontally at a tree that is 15m away. When the snowball is released it is 4.0m above the ground on which the tree stands. The snowball hits the tree 0.60 seconds after it has been released.



a) What is the horizontal velocity at which the snowball was thrown? (3 marks)

$t = 0.60$ sec

$s_H = 15$ m

$= u_H t + \frac{1}{2} a_H t^2$, $a_H = 0$

$u_H = \frac{s_H}{t} = \frac{15}{0.6} = \underline{\underline{25 \text{ ms}^{-1}}}$ (3)

b) Approximately how far above the level ground does the snowball hit the tree? (3 marks)

$s_V = u_V t + \frac{1}{2} g t^2$ NOTE +ve down

$u_V = 0 \text{ ms}^{-1}$

$= 0 \times 0.6 + \frac{1}{2} \times 9.8 \times 0.6^2 = \underline{1.76 \text{ m}}$ below launch position (2)

height up tree $= 4.00 - 1.76$

$= \underline{\underline{2.24 \text{ m}}}$ (1)

Question 15: (contd)

c) At what **velocity** does the snowball hit the tree? (5 marks)

$u_H = 25.0\ ms^{-1}$

$v_H = 25.0\ ms^{-1}$

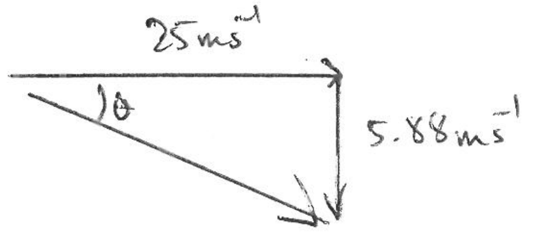
$u_v = 0\ ms^{-1}$

$v_v = u_v + gt$ +ve down

$= 0 + 9.8 \times 0.6$

$= \underline{5.88\ ms^{-1}}$ down   2

velocity = vector sum of vert + horiz vels



1

$v = \sqrt{25^2 + 5.88^2} = \underline{\underline{25.7\ ms^{-1}}}$ 1

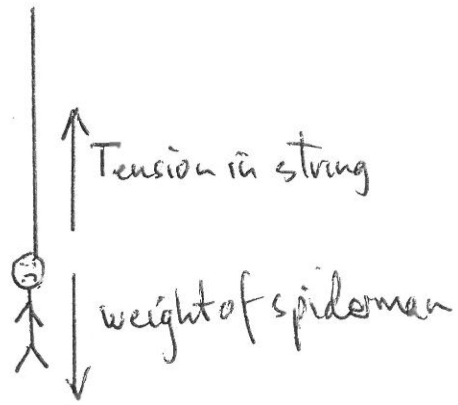
$\theta = \tan^{-1} \frac{5.88}{25} = \underline{\underline{13.2^\circ}}$ 1

vel = $\underline{\underline{25.7\ ms^{-1} \text{ at } 13.2^\circ \text{ to horizontal}}}$

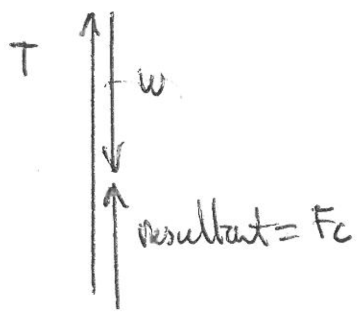
Question 16: (9 marks)

Spiderman has a mass of 80.0 kg. He swings in a vertical, circular arc on a web that is 4.00 m long.

a) Draw a free body diagram of the force acting on Spiderman at the bottom of the swing. (2 marks)



b) If his speed is 3.20 ms^{-1} at the bottom of the swing, what is the tension in the web? (4 marks)



$$F_c = T - w \Rightarrow T = F_c + w$$

$$= \frac{mv^2}{r} + mg$$

$$= \frac{80 \times 3.2^2}{4.00} + 80 \times 9.8$$

$$= \underline{\underline{989\,N}} \quad \underline{up}$$

c) If the maximum tension the web can withstand is 1800 N, what is the minimum speed Spiderman would have to have at the bottom in order to break the web? (3 marks)

$$T = \frac{mv^2}{r} + mg \qquad (1) \qquad T = 1800\,N$$

$$1800 = \frac{80 \times v^2}{4.0} + 80 \times 9.8 \qquad (1)$$

$$v^2 = (1800 - 80 \times 9.8) \times \frac{4.0}{80.0} = 50.8$$

$$\underline{\underline{v = 7.13\,ms^{-1}}} \qquad (1)$$

Question 17: (11 marks)

a) Two spheres, each having a mass of 40.0 kg are positioned so that their centres are 8.00 m apart. What is the gravitational force of attraction between the two spheres? (4 marks)

$m = 40.0\,kg$

$d = 8.00\,m$

$$F = \frac{m_1 m_2}{d^2} G$$

$$= \frac{40.0 \times 40.0 \times 6.67 \times 10^{-11}}{8.00^2}$$

forget square

$$= \underline{1.67 \times 10^{-9}\,N} \text{ (attraction)}$$

(-1)

b) If the mass of one of the spheres in part a) was doubled, how far apart would the spheres have to be placed to maintain the same force of gravity? (3 marks)

$$F = \frac{m_1 m_2}{d^2} G = 1.67 \times 10^{-9} = \frac{40 \times 80 \times 6.67 \times 10^{-11}}{d^2}$$

$$d^2 = 128$$

$$\underline{d = 11.3\,m}$$

c) On a popular science TV show, the host described the orbiting space shuttle astronauts as being "weightless" because they were in a "zero gravity" environment.

(i) Using field concepts, explain why the phrase "zero gravity" **should not** be used. (2marks)

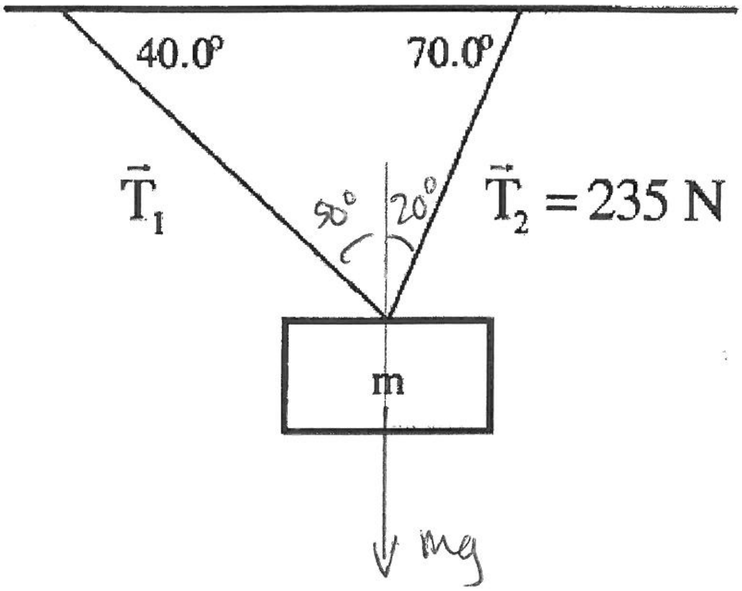
If the astronaut was orbitting earth - there is a gravitational field acting on him therefore he is not in a region of "zero gravity"!

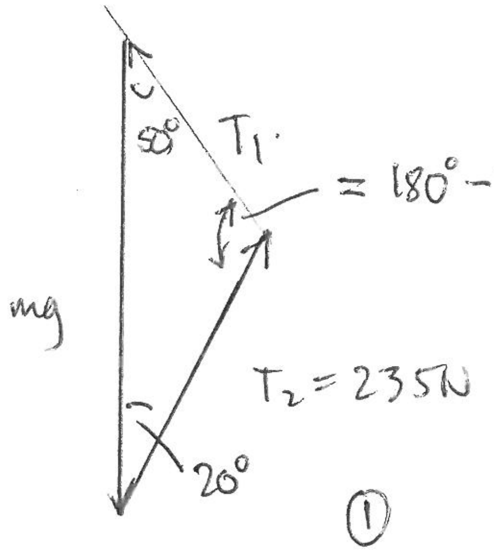
(ii) Explain why the astronauts **feel** weightless. (2 marks)

They are falling. The net force on the astronaut is zero, thus they do not feel a weight force ∴ they feel weightless

Question 18: (5 marks)

The accompanying diagram shows a mass suspended in equilibrium by two ropes. Calculate the mass m.





$= 180° - 70° = 110°$

(1)

Sine rule

$$\frac{mg}{\sin 110°} = \frac{235}{\sin 50°} \quad (1)$$

$$mg = \frac{235 \sin 110°}{\sin 50°}$$

$$= 288 \text{ N} \quad (1)$$

$$m = \frac{288}{9.8} = 29.4 \text{ kg}$$

(2)

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OR Using Simultaneous Equation

$\sum F_v = 0 \quad T_2 \cos 20^\circ + T_1 \cos 50^\circ = mg. \quad — ①$ (1)

$\sum F_a = 0 \quad T_2 \sin 20^\circ = T_1 \sin 50^\circ \quad — ②$

$T_1 = \dfrac{T_2 \sin 20^\circ}{\sin 50^\circ} \quad — ②$ (1)

$T_2 \cos 20^\circ + \dfrac{T_2 \sin 20^\circ}{\sin 50^\circ} \cdot \cos 50^\circ = mg$ (1)

$235 \left(0.9397 + \dfrac{0.3420 \times 0.6248}{0.7660} \right) = mg$

$mg = \underline{288\ N}$

$\underline{\underline{m = 29.4N}}$ (2)

Question 19: (13 marks)

Over the past year or so astronomers have discovered many planets orbiting distant stars. The following data gives the planetary orbital period **T** as a function of distance **r** from the central star.

T (seconds)	2.43×10^5	4.47×10^5	6.91×10^5
r (10^9m)	10.0	15.0	20.0
(T^2) sec^2	5.90×10^{10}	19.98×10^{10}	47.7×10^{10}
(r^3) $(10^{27} m^3)$	$10^3 = 1000$	$15^3 = 3375$	$20^3 = 8000$

This data is related to the Kepler's Law equation:

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

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

$$y = m \quad x$$

T = orbital period (seconds)
r = orbital radius (m)
G = gravitational constant (N m^2kg^{-2})
M = mass of central star (kg)

x axis (r^3)
y axis (T^2)

(a) Modify the above data to enable you to plot a straight-line graph relating period to orbital radius. Write your modified data in the **blank spaces in the table above**, including the units that you are using. (4 marks)

✓

(b) Plot the modified data on the graph on the **opposite page**. (4 marks)

(c) **Describe** how this graph can be used to determine the **mass** of the central star. (3 marks)

note mass = M slope = m

$$m = \frac{4\pi^2}{GM} \quad \therefore \quad M = \frac{4\pi^2}{G(\text{slope})}$$

(d) Using the graph, determine the value of the **mass** of the central star. (2 marks)

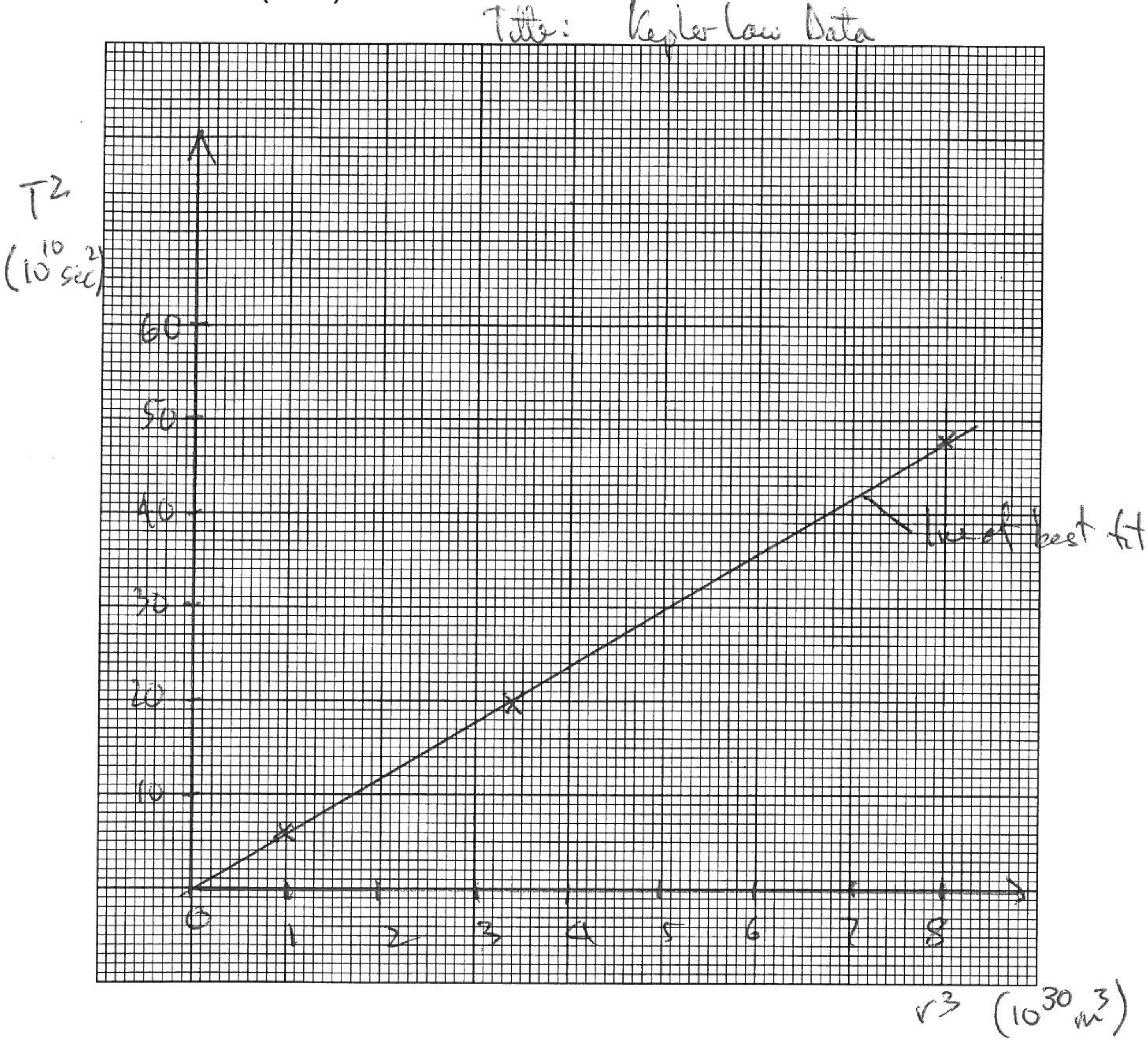
$$\text{slope} = \frac{y_2 - y_1}{x_2 - x_1} = \frac{48 - 0}{8 - 0} = 6.0$$

$$\text{units} = \frac{10^{10}}{10^{30}} = 10^{-20}$$

$$\text{slope} = 6.0 \times 10^{-20}$$

$$\therefore \text{Mass} = \frac{4 \times \pi^2}{6.67 \times 10^{-11} \times 6 \times 10^{-20}} = \underline{9.86 \times 10^{30}\ kg}$$

Question 19: (contd)



axes 2

lobf 1

title 1

TOT 4