H2 Physics

Year 1 Revision (Part 2)

Source:
Structured Questions

1. Measurement
2. Kinematics
3. Dynamics
4. Forces
5. Work, Energy and Power
6. Thermal Physics



1 A cylindrical thermos flask is used to store hot water. The internal diameter and depth of the thermos flask are measured to be (8.50 ± 0.01) cm and (17.0 ± 0.1) cm respectively.

(a) State the instrument used to measure its diameter and a systematic error that can occur with the use of this instrument.

.....

[2]

.....

(b) Calculate the capacity of the thermos flask and its associated uncertainty.

Volume = ... cm^3 [3]

2 **(a)** Distinguish between a random error and a systematic error in the measurement of a physical quantity. [2]

(b) A student set up the apparatus shown in Fig 1 in order to determine the spring constant k of a spring by finding the extension of the spring when additional mass is loaded.

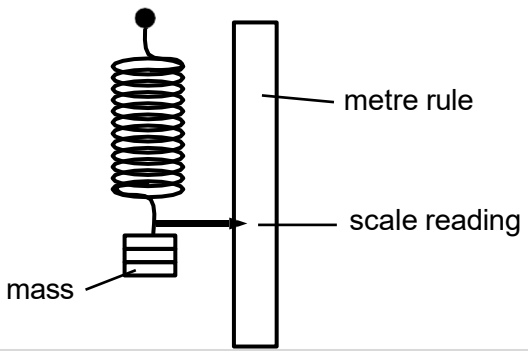


Fig 1

The following readings with their errors were recorded in a particular experiment:

mass added	initial scale reading	final scale reading
(20 ± 1) g	(32.00 ± 0.05) cm	(36.30 ± 0.05) cm

Using the readings above, calculate the spring constant k with its associated uncertainty and present your answer in SI units of N m^{-1}. [4]

(c) A second student repeated the experiment in (b) with the same spring. In this new experiment, the additional masses were loaded and the corresponding extension readings were tabulated. A graph showing the variation of the extension and loaded masses was then plotted. Discuss three advantages of this procedure for the determination of the spring constant as compared to that used in (b).

[3]

3 **(a)** Give **reasonable** estimates of the following quantities. In each case, give your answer in an SI unit.

(i) The volume of the 2010 official World Cup soccer ball.

volume = ... m^3 [1]

(ii) The kinetic energy of an olympic sprinter near the ending point of a 100-metre dash.

Kinetic energy = ... J [1]

(iii) The density of the head of a human being.

density = ... kg m^{-3} [1]

(b) An experiment is conducted to determine the density of cooking oil, which *floats* on water. Three sets of results are obtained from the experiment. The unit for density is kg m^{-3}.

A	B	C
810	1500	740
800	1490	870
805	1495	790

(i) Which set of results is precise but inaccurate? Explain your reasoning.

.....

.....

.....

.....

..... [2]

(ii) Assuming the measurement of volume has been done correctly, suggest one possible source of experimental error that causes the aforementioned set of results inaccurate.

.....

.....

..... [1]

4 (a) Complete Fig. 1.1 to show each quantity and its base units. [2]

quantity	base units
speed	$m\ s^{-1}$
density	$kg\ m^{-3}$
.....	$kg\ m\ s^{-1}$
electric field strength	.....

Fig. 1.1

(b) In the classroom, a student wishes to determine the mass of a plastic semi-circular protractor.

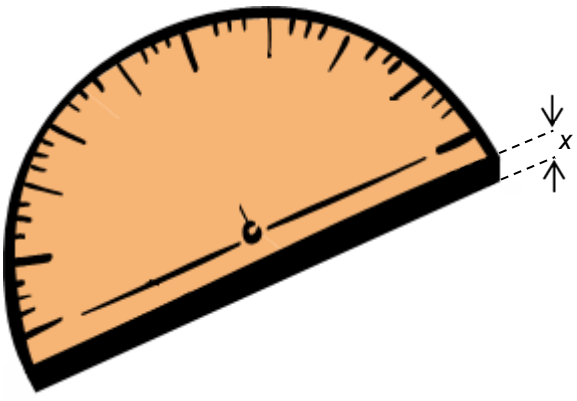


Fig. 1.2

(i) Give a **reasoned** estimate of the mass of the semi-circular protractor and express your answer in an SI unit.

mass = …… unit ..... [2]

(ii) State an instrument which is most appropriate for the measurement of the thickness of the protractor *x*, as indicated in Fig. 1.2.

…..... [1]

(iii) For the measurement of *x*, suggest a way to reduce random errors.

…..……..…….

…..... [1]

5. (a) Distinguish between a scalar quantity and a vector quantity, providing an example for each.

……

……

….....[2]

(b) A ship is initially cruising in the direction bearing of 045 at a speed of 10 m s^{-1} changes direction to head in a new direction bearing of 145 at a speed of 5 m s^{-1}, as seen in **Fig. 1.1**. The manoeuvre was completed in 30 s.

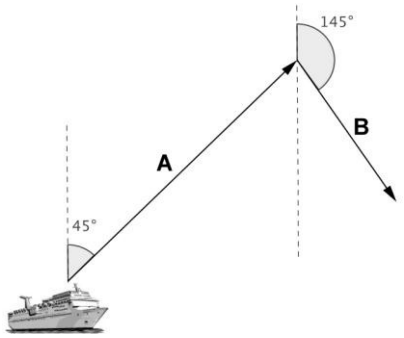


Fig. 1.1

Using a vector diagram or otherwise, calculate the acceleration of the ship during the change in direction.

acceleration of the ship =……..m s^{-2} at bearing of.....[3]

6 **(a)** Distinguish between systematic and random errors.

……

……

……

……

[2]

(b) There are two possible methods of measuring the volume of a cylindrical container. The first method is by measuring the inner diameter and the height of the container and calculating the volume. The readings are as follows:

Inner diameter = 2.57 ± 0.01 cm
Height = 7.8 cm ± 0.1 cm

The second method is by filling the container with water, and then pouring the water out into a measuring cylinder. The measuring cylinder can read to the nearest cm^3. With the aid of suitable calculations, explain which method would give more precise value of the volume.

.....

.....

.....

.....

[3]

7 When a solid is heated, the thermal energy required is given by the expression

gain in thermal energy = mass X c X temperature rise, where c is a constant.

(a) Name the quantities in the expression that are SI base quantities.

……..... **[1]**

(b) Express, in terms of SI base units, the units of

(i) thermal energy,

unit of thermal energy = ……

[2]

(ii) the constant c.

unit of c = ……

[2]

8 Most Singapore buildings are built using a framework of concrete beams, slabs and columns. The concrete columns need to carry both the ultimate vertical load, *N* and the ultimate bending moment, *M* induced from the attached beam/s as shown in the 3-D pictorial diagram of **Fig. 6.1**. In practice, the concrete columns are reinforced with steel bars.

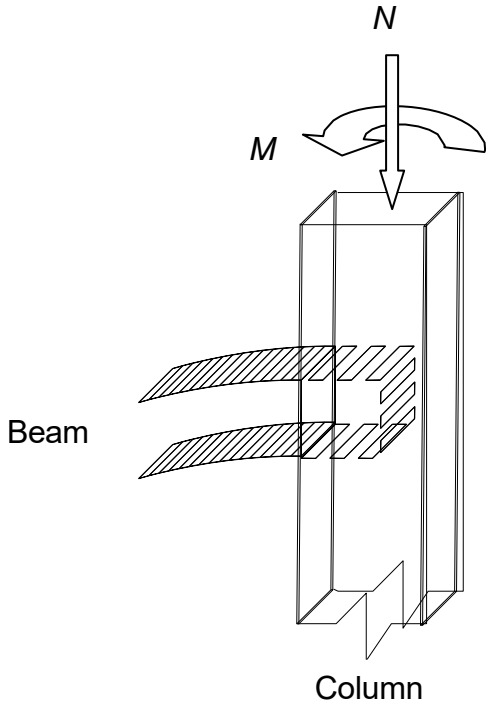


Fig. 6.1

To design for the steel bars in such columns, design charts are available from the *British Standard Structural Use of Concrete, BS8110*.

In order to choose the correct design chart, the values of the following must match the design details:

f_{cu} = Ultimate crushing pressure limit of concrete
f_y = Ultimate characteristic strength of steel bar
$\frac{d}{h}$ where d is the distance from the edge of the column to the centre of the steel bar that is furthest from that edge and h is the larger dimension of the column

The cross section of a column is shown in **Fig. 6.2**:

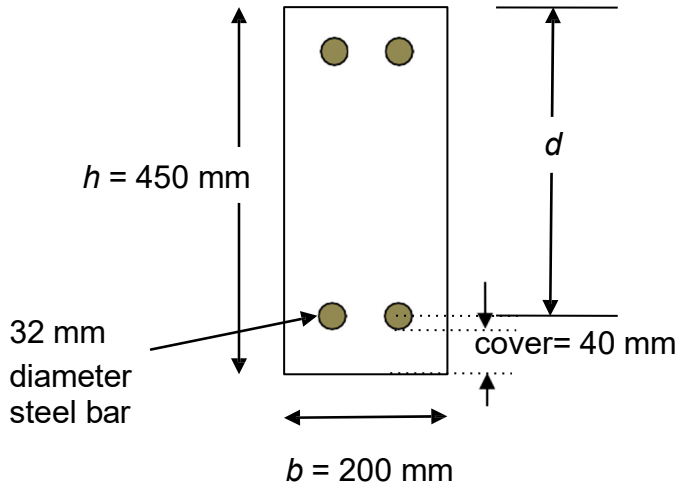


Fig. 6.2

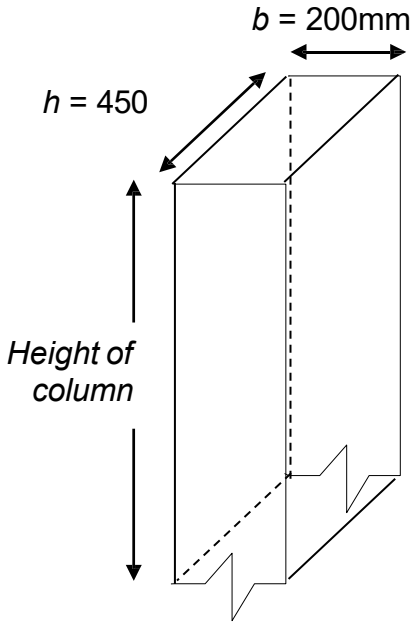


Fig. 6.3

Dimensions of the column
h = 450 mm (larger dimension of the column)
b = 200 mm
d = distance from the edge of the column to the centre of the steel bar that is furthest from that edge.

(a) The chosen design details for the column above are:

f_{cu} = 50 N mm^{-2}
f_y = 460 N mm^{-2}
cover = 40 mm (from edge of column to edge of steel bar)

Assuming that 4 numbers of 32 mm diameter steel bars are to be used. Determine the value of $\frac{d}{h}$ and hence explain why **Chart No. 49** is appropriate to be used.

$\frac{d}{h}$ = ... [1]

Explanation:

.....

..... [1]

(b) The coordinates of the chart derived from the values of $\frac{N}{bh}$ and $\frac{M}{bh^2}$ can be used to establish the corresponding value of $\frac{100A_{SC}}{bh}$ such that A_{SC} (the total required cross-sectional area of steel bars) can be calculated. It is necessary to provide enough steel bars, with a total area more than A_{SC}.

An example of reading off the $\frac{100A_{SC}}{bh}$ value is:

Value of $\frac{N}{bh}$ = 32.5 N mm^{-2}
Value of $\frac{M}{bh^2}$ = 3.20 N mm^{-2}

From **Chart No. 49**, the corresponding coordinate is marked with a cross and labelled '**A**'. This coordinate corresponds to a value of $4 < \frac{100A_{SC}}{bh} < 5$. More specifically, the value of $\frac{100A_{SC}}{bh}$ is 4.5. Using this value, A_{SC} can then be calculated.

Based on the same design details in **(a)**, the loads carried by the column in **Fig 6.2** are:
M = Ultimate bending moment = 91.2 kN m
N = Ultimate vertical load = 2460 kN

(i) Determine the values of $\frac{N}{bh}$ and $\frac{M}{bh^2}$ for the column in **Fig 6.2**.

$\frac{N}{bh}$ =.....N mm^{-2}
$\frac{M}{bh^2}$ = …… N mm^{-2} [2]

(ii) Using **Chart No. 49**, determine whether 4 steel bars of diameter 32 mm with a total area of 3220 mm^2 is sufficient. [4]

(c) A young engineer designed the same column except that he used a different concrete with an ultimate crushing pressure limit, f_{cu} of 25 N mm^{-2}. Compare your calculated value of $\frac{N}{bh}$ in **(b)(i)** with this value of f_{cu} = 25 N mm^{-2}. Comment what would happen to the concrete.

.....

.....

..... [2]

(d) The height of the column designed is 3.8 m. Suggest one possible problem with another 12.0 m height column of similar size subjected to a similar vertical load and bending moments.

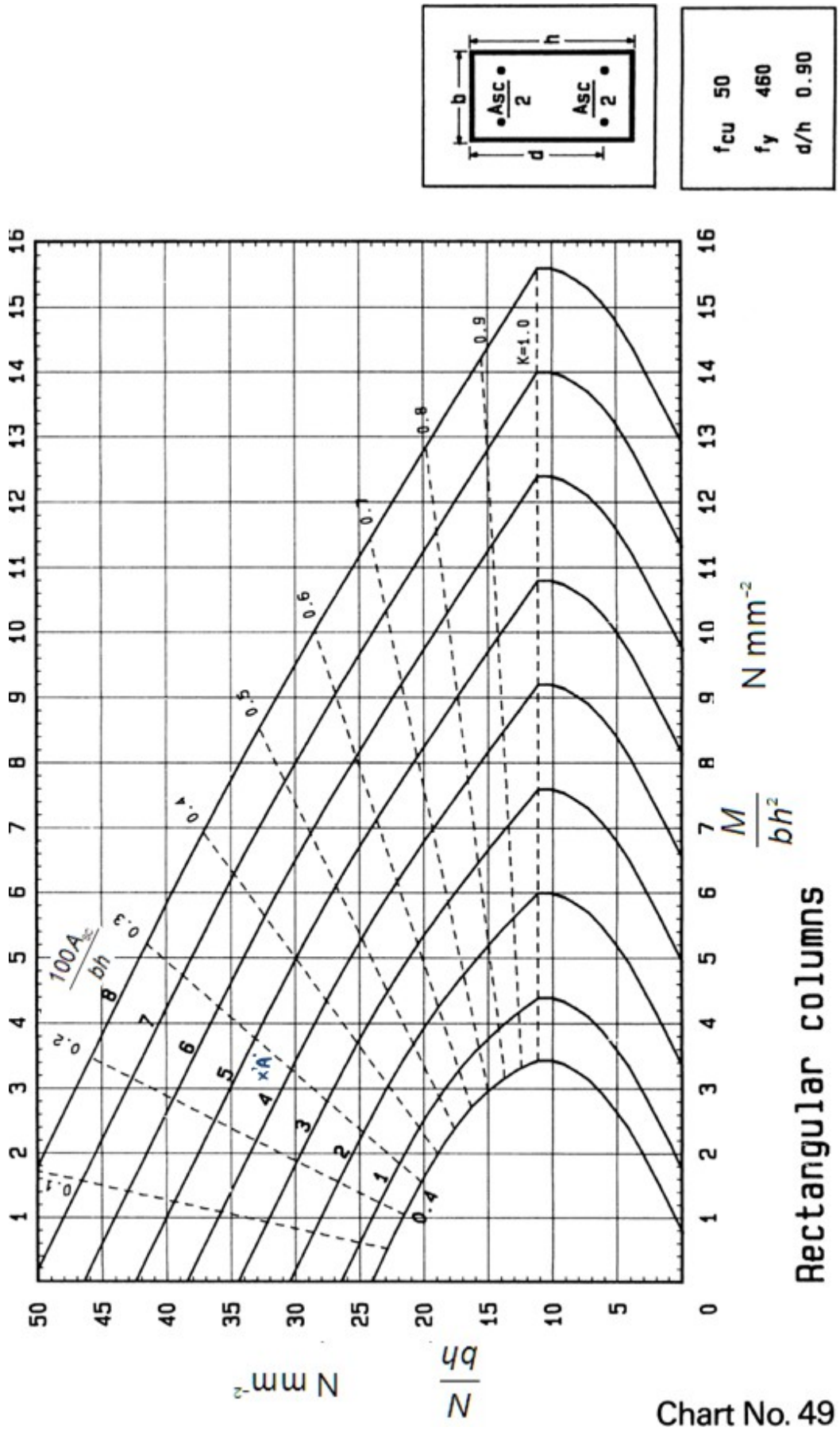
.....

..... [1]

(e) The design of another column has the values of $\frac{100A_{SC}}{bh} = 2.0$ and $\frac{M}{bh^2} = 2.0$.

Using **Charts No. 39** and **49**, determine the percentage decrease in ultimate vertical load, N if f_{cu} = 50 N mm^{-2} changes to f_{cu} = 40 N mm^{-2}.

Percentage decrease of N =..... % [4]


Rectangular columns
Chart No. 49
$\frac{M}{bh^2}$ N mm^{-2}
$\frac{N}{bh}$ N mm^{-2}
$\frac{100A_{sc}}{bh}$
K=1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
f_{cu} 50
f_y 460
d/h 0.90
b
h
d
$\frac{Asc}{2}$
$\frac{Asc}{2}$

9) (a) In a certain equation,

$$A = \frac{C^4 D}{E^2 (B_1 - 3B_2)} \sqrt{\frac{F^{12}}{H^4}}$$

where *C* has unit Newtons, *D* has the unit metres, *E* has the unit Pascal, *B1* and *B2* have the unit metres, *F* has the unit metres, and *H* has the unit Joules.

(i) Determine the unit of *A*.

(ii) The value of *C* is (2.05 □ 0.02) x 10-9 m, what percentage uncertainty does this introduce into the value of *A*?

(b) Peter decides to go skydiving. From an altitude of 3500 m, he jumps off the aircraft. He delays opening his parachute until he reaches 800 m. He attains terminal velocity before he reaches 800 m. Assume that he falls vertically.

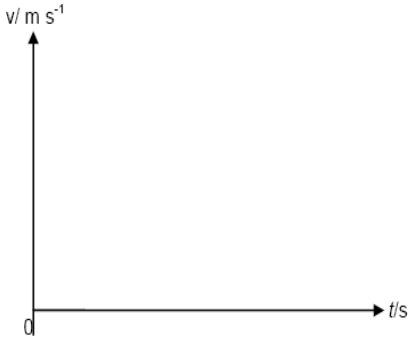
(i) Describe qualitatively, and with an explanation, Peter's motion after he jumped off till he reaches terminal velocity.

……..……
……...……..…
..... [1]

(ii) When Peter opens his parachute, his velocity is 55 m s-1 downwards. His landing speed is 4 m s^{-1}.
Sketch a velocity- time graph from the time Peter has just started falling at $t = 0$ s until he is about to land.

The time till which Peter lands is not needed.

Note that when the parachute is first opened, the force by the parachute on Peter is larger than his weight. [2]



(iii) Explain the shape of the graph from the time the parachute opens till the landing.

……
……
……
……[2]

END

2010 NYJC H2 P3 Q1

1 **(a)** Define *acceleration*.

.....

_____[1]

(b) A boy throws his slipper from a height of 1.0 m at 75° above the horizontal in an attempt to hit a durian hanging on a tree which is 4.75 m above the ground. The slipper reached its maximum height of 0.25 m directly below the durian. Neglect air resistance.

(i) Calculate the velocity of the slipper when the slipper leaves the boy's hand.

velocity = _____ m s^{-1} [2]

(ii) Calculate the horizontal distance travelled when his slipper hits the ground.

distance = _____ m [2]

(iii) Sketch a labelled velocity - time graph for the **vertical component** of the slipper from the time it leaves the boy to the time when it hits the floor.

[2]

(iv) If the velocity calculated in part **(b)(i)** is the maximum velocity he can provide when throwing his slipper, suggest with a reason what he should do in order to ensure his slipper hits the durian.

.....

_____[1]

2 **(a)** Define *velocity* and *acceleration*.

.....

.....

..... [2]

(b) Fig. 1.1 shows the variation with time t of the velocity v for an object.

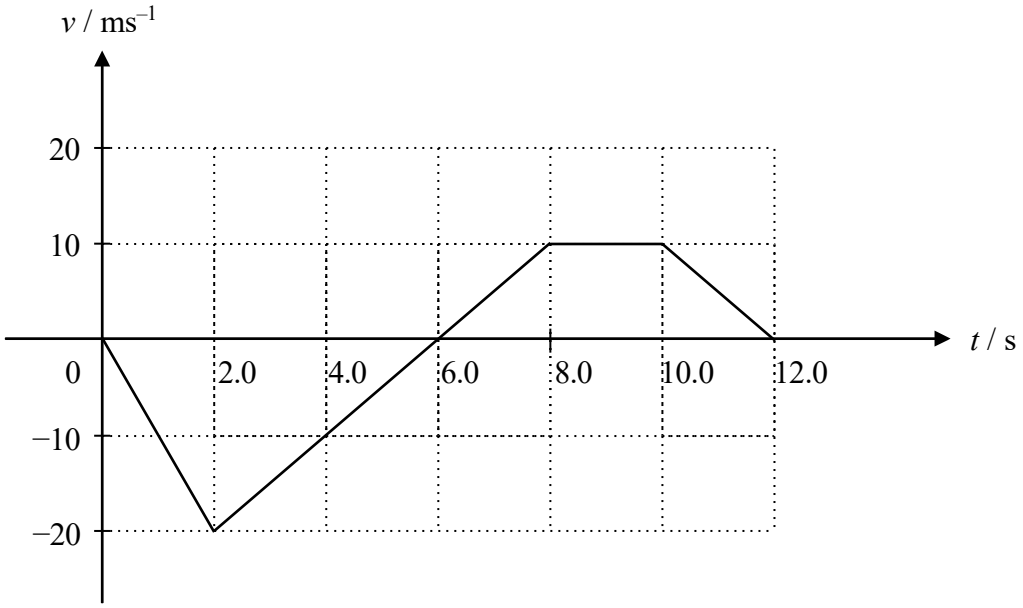


Fig. 1.1

(i) State the time at which the object is at maximum displacement from the starting point.

time = ... s [1]

(ii) Calculate the displacement of the object at $t = 12.0$ s.

displacement = ... m [1]

(iii) On Fig. 1.2, sketch a graph to show the variation with time t of the displacement s for the object. (You are not expected to label values of the displacement.) [2]

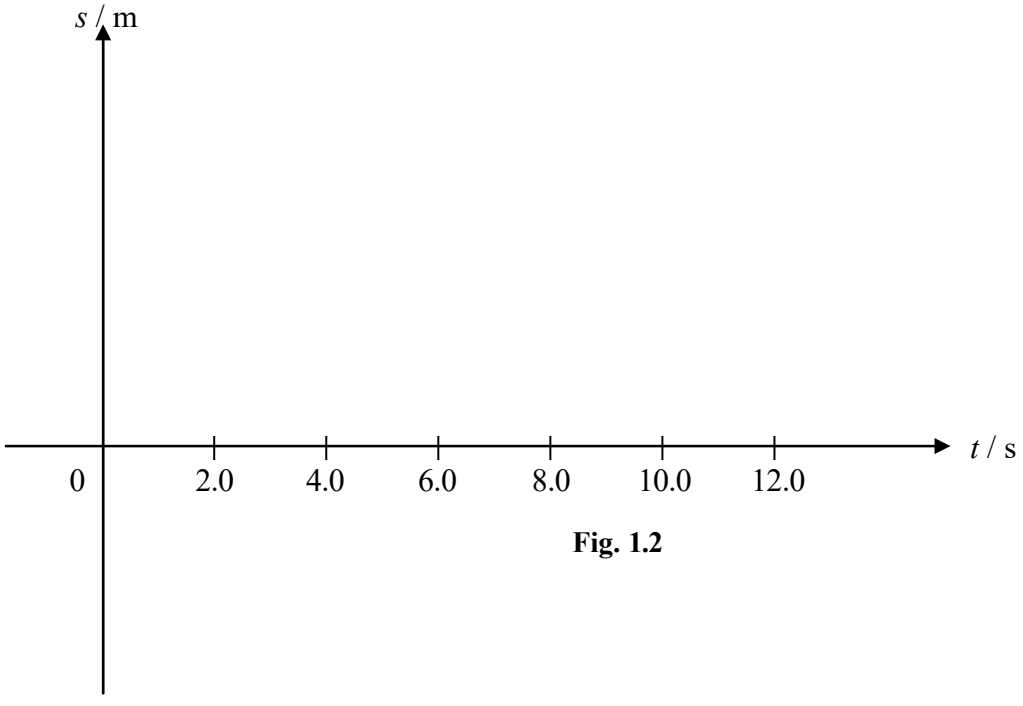


Fig. 1.2

3 **(a)** A lecturer holds a flat S$2 note just above a student's open fingers as shown in Fig. 1.1.



Fig. 1 1

He challenges the students that whoever can catch the S$2 note when he releases it can keep it. Explain quantitatively whether any student would be able to catch the note when the lecturer releases it.

[3]

(b) A lecturer sees a student who owes him homework a distance d away. The lecturer immediately moves towards the student with a constant velocity v_L. The student sees the lecturer moving towards him t_0 seconds later and starts moving away in the same direction at a constant velocity v_S.

Write down an expression for the time taken t for the lecturer to catch up with the student from the instant he sees the student. Show your derivation clearly.

[4]

4 locity-time graph in Fig. 1.1 shows the first 1.6 s of the motion of a ball which is thrown vertically downward at an initial speed of 6.0 m s^{-1}.

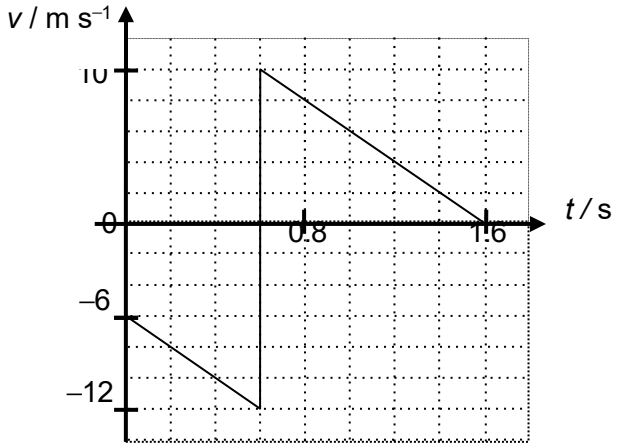


Fig. 1.1

(a) How far does the ball travel before hitting the ground?

distance travelled =

(b) What is the maximum height attained by the ball after it hits the ground?

maximum height =

(c) Calculate the magnitude of the acceleration of the ball when it is in the air.

acceleration = ...

(d) At what time does the ball next reach the ground?

time = _____]

(e) upward direction to be positive, sketch on Fig. 1.2, a clearly labelled displacement-time graph for the motion of the ball from time t = 0 up to the second time it hits the ground.

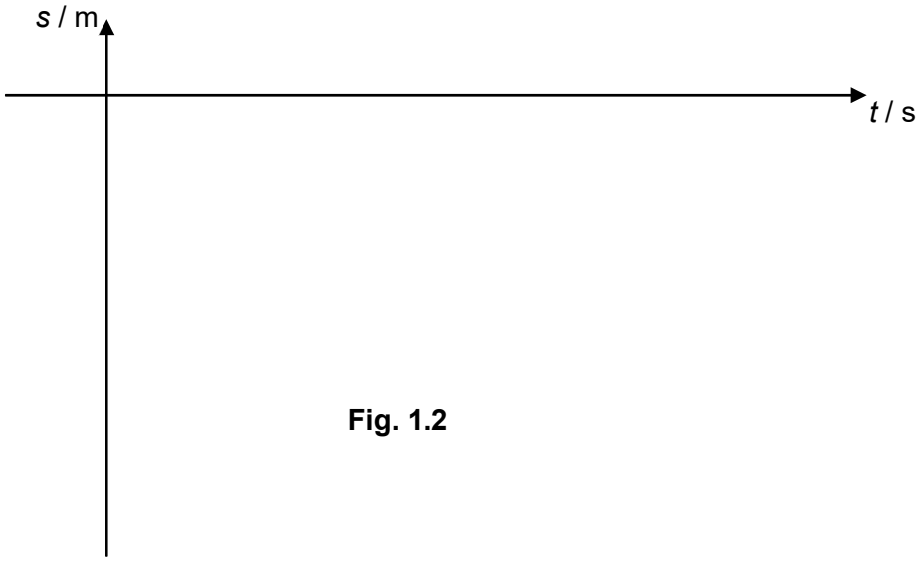


Fig. 1.2

5. The figure below shows a juggler performing a trick called "the shower" in which three balls are kept moving around between the two hands and through the air in the trajectory shown in Figure 1.

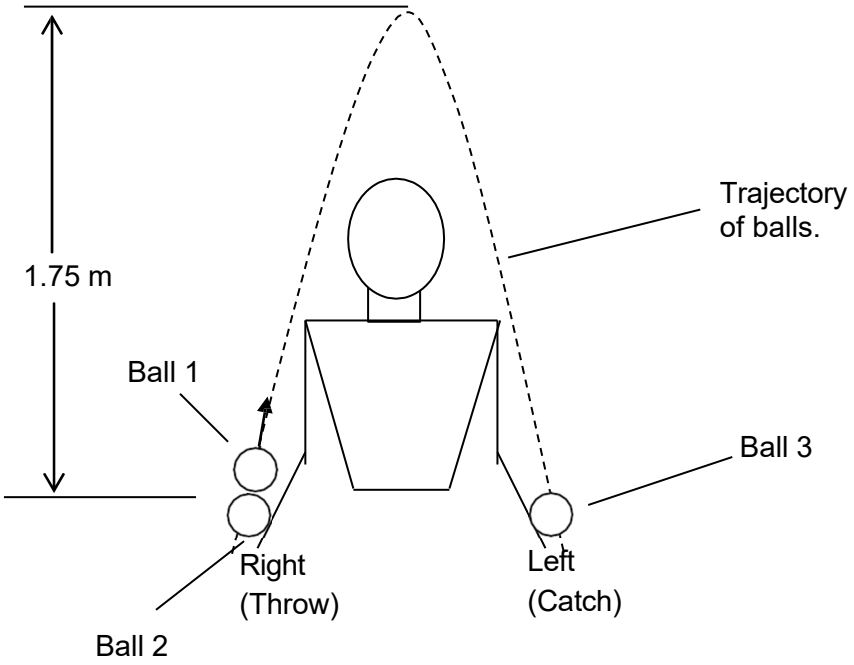


Figure 1

(a) Ball 1 leaves the right hand at an angle of 80.0° to the horizontal and reaches a maximum height of 1.75 m above the level of the juggler's hands. Show that ball 1's initial speed of projection must be 5.95 m s^{-1}.

[2]

(b) Calculate how far the juggler must position his hands apart so that the ball lands on his left hand.

distance =_____m [2]

(c) For a fixed speed of projection, suggest two advantages for the juggler to throw the balls at such a large angle to the horizontal

Advantage 1:

_____

_____

_____[1]

Advantage 2:

_____

_____

_____[1]

(d) When Ball 1 is just at its maximum height, the juggler throws Ball 2 up with the same speed and in the same direction as he did Ball 1. How much time does the juggler have to transfer Ball 3 from his left to right hand so that his left hand is available to catch Ball 1?

time = _____s [1]

(e) Suggest a minimum value for the horizontal distance between the two hands and explain your answer clearly.

_____

_____

_____[2]

6 'Clay pigeon shooting' is a sport whereby the shooter aims and hits the clay disc projected by a launcher. A certain clay disc is launched from the horizontal ground with a velocity of 20 m s^{-1} at an angle of 30^{o} to the horizontal.

(a) Assuming that air resistance can be neglected, calculate

(i) the maximum height of the disc,

maximum height = ... m [2]

(ii) the horizontal distance between the point from which the disc is launched and where it lands on the ground.

horizontal distance = ... m [2]

(b) The path **N** for the above disc is as given in Fig. 2.1 where air resistance is neglected.

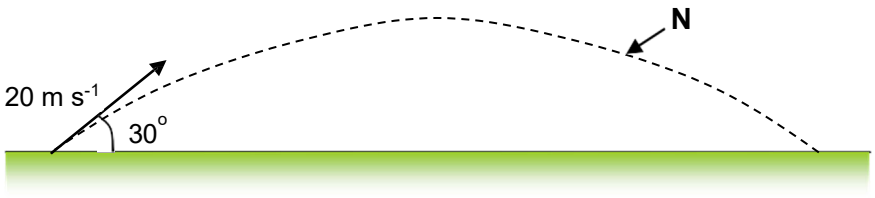


Fig. 2.1

(i) Draw the path of the clay disc on Fig. 2.1, assuming that air resistance cannot be neglected. Label this path **A**. [1]

(ii) Suggest an explanation for any differences between the two paths **N** and **A**.

……

……

……

…… [2]

7 The speed limit of one segment of the Pan Island Expressway is 90 km h^{-1}. A police radar speed detector detects a motorcycle moving at a constant speed of 35 m s^{-1}. 20 seconds later, a police car, hiding at a distance 100 m after the speed detector, accelerates from rest at 4.0 m s^{-2} for 13.0 s to reach its top speed.

(a) Show that the motorcycle has exceeded the speed limit stated. [1]

(b) Calculate the top speed of the police car. [1]

(c) When the police car just reached its top speed, calculate the distance between the motorcycle and the police car. Show your working clearly. [4]

(d) How long does the police car take to catch up with the motorcycle, after reaching its top speed? [2]

8. (a) A body *accelerates at 10 m s^{-2}* over a period of time.

Explain what is meant by the phrase in italics.

……

….....[1]

(b) A Singapore Army soldier is undergoing marksmanship training by firing at the target, as seen in **Fig. 2.1** below. He uses the SAR 21 Rifle, which has a muzzle velocity (velocity at which the bullet exits the rifle) of 900 m s^{-1}.



Fig. 2.1

He ensures his rifle is perfectly horizontal while aiming for the head of the target. He then fires a bullet at the target, which is 300 m away from his current position.

(i) Calculate the time taken for the bullet to reach the target after it is fired.

time taken =…..... s [1]

(ii) What is the assumption made in this calculation?

……

……[1]

(iii) Assuming that it is a perfect shot (i.e. the rifle was perfectly horizontal and was aimed properly at the head of the target), calculate the vertical distance between his aiming point and where the bullet actually hits the target.

vertical distance =.....m [2]

(iv) After passing through the target, the bullet is entrenched 4.0 m deep into a sandbag that is directly behind the target board.

Calculate the average deceleration of the bullet as it moves within the sandbag

average deceleration =… ..... m s^{-2} [2]

(v) If the assumption was not made in **(b) (ii)**, state whether the bullet would hit the target at a lower or higher point than what was calculated in **(b) (iii)**.

……

……[1]

9 An aeroplane is flying horizontally at a steady speed of 67 m s^{-1} and an object is dropped off from the aeroplane.

(a) Assume that the air resistance is negligible.

(i) Show that the vertical component of the velocity of the object is approximately 40 m s^{-1} when it has fallen 80 m. [2]

(ii) Determine the magnitude and direction of the resultant velocity of the object at this point.

Magnitude of velocity =. ..... m s^{-1}

Direction of velocity =..... **[3]**

(b) In practice, air resistance acts on the object during the fall. The air resistance may be assumed to be proportional to the square of the speed.

State and explain how the magnitude of the horizontal and vertical components of the velocity of the object vary with time.

Horizontal component of velocity:

.....……...

.....……...

.....……... **[1]**

Vertical component of velocity:

.....……....

.....……....

.....……...

.....……... **[2]**