KINEMATICS

Challenging **MCQ** questions by The Physics Cafe

Compiled and selected by The Physics Cafe

1 **(a)** A body has an initial velocity *u* and an acceleration a. After a time *t*, the body moved a distance *s* and has a final velocity *v*. One of its equation of motion is

$$s = ut + \frac{1}{2}at^2.$$

State the conditions that must be satisfied for the above equation to be valid.

……

…….. [2]

(b) A hot air balloon was rising steadily at a speed of **10.0 m s^{-1}** when weather conditions turned windy. A constant breeze of **3.0 m s^{-1}** blew horizontally across the sky, which caused the hot air balloon to travel with a resultant velocity of v_R at an angle θ to the horizontal, as shown in Fig. 1.1 below.

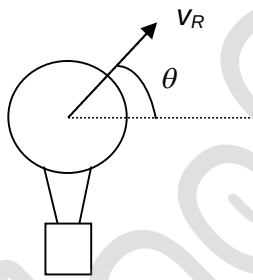


Fig. 1.1

(i) Calculate the magnitude and direction of the resultant velocity v_R.

θ = …….. ^{o}

v_R = …….. m s^{-1}

[2]

(ii) A sandbag was dropped from the balloon.

1. In Fig. 1.2, sketch the path of trajectory of the sandbag as it drops from the balloon.

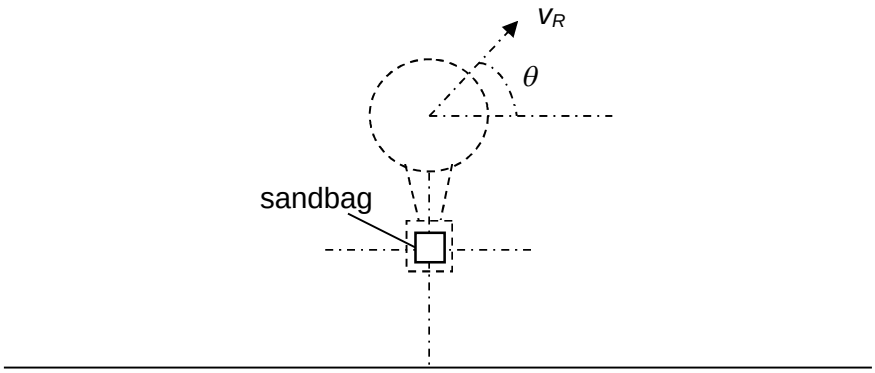


Fig. 1.2

[1]

2. Determine how far below the balloon would the sandbag be after **4.0 s**. You may assume that the sandbag had not landed on the ground, the dropping of sandbag did not affect the velocity of the hot air balloon and that air resistance on the sandbag is negligible.

distance = …… m [3]

Ans **a** Conditions for equations to be valid:

- Constant acceleration
- Motion in a straight line

b(i)

$$v_R = \sqrt{\left(v_x^{\,2} + v_y^{\,2}\right)}$$

$= \sqrt{(10.0^2 + 3.0^2)}$

$= 10.44$

$\approx 10 \text{ m s}^{-1}$

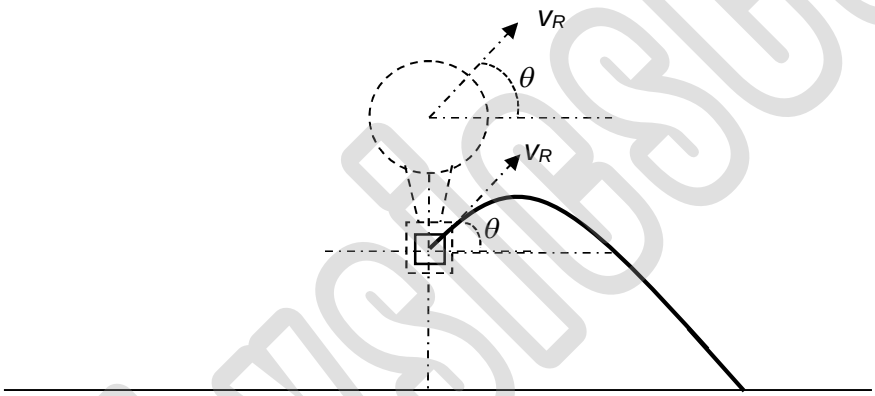
$\theta = \tan^{-1}\left(\frac{10}{3}\right)$

$= 73.3°$

$\approx 73°$

b(ii) 1. Initial velocity of sandbag is v_R with angle θ to horizontal.

Path is symmetrical and parabolic



bii 2. Taking downwards as positive,

$S_{bag} = -10.0\ (4.0) + \frac{1}{2}(9.81)(4.0)^2$

$= 38.48 \text{ m}$

$S_{balloon} = -\ 10.0\ (4.0) = -\ 40.0\text{m}$

Distance apart = $40.0 + 38.48 = 78.48 \approx 78$ m

2 An object is launched at a speed of **30 m s^{-1}** at an angle of **30^{o}** from a horizontal surface as shown in Fig. 2.1. Ignore air resistance.

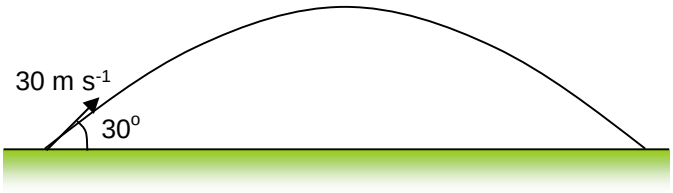


Fig. 2.1

(a) Find the time taken for the object's entire journey.

time taken = …….. s **[2]**

(b) Hence, or otherwise, find the range of the launch.

range = …….. m **[1]**

(c) State another angle with which the object can be launched such that it will travel the same range in (b).

angle = ……..$^{\circ}$ **[1]**

(d) Sketch the variation of the vertical component of the velocity with time on Fig. 2.2. Label it as **A**.

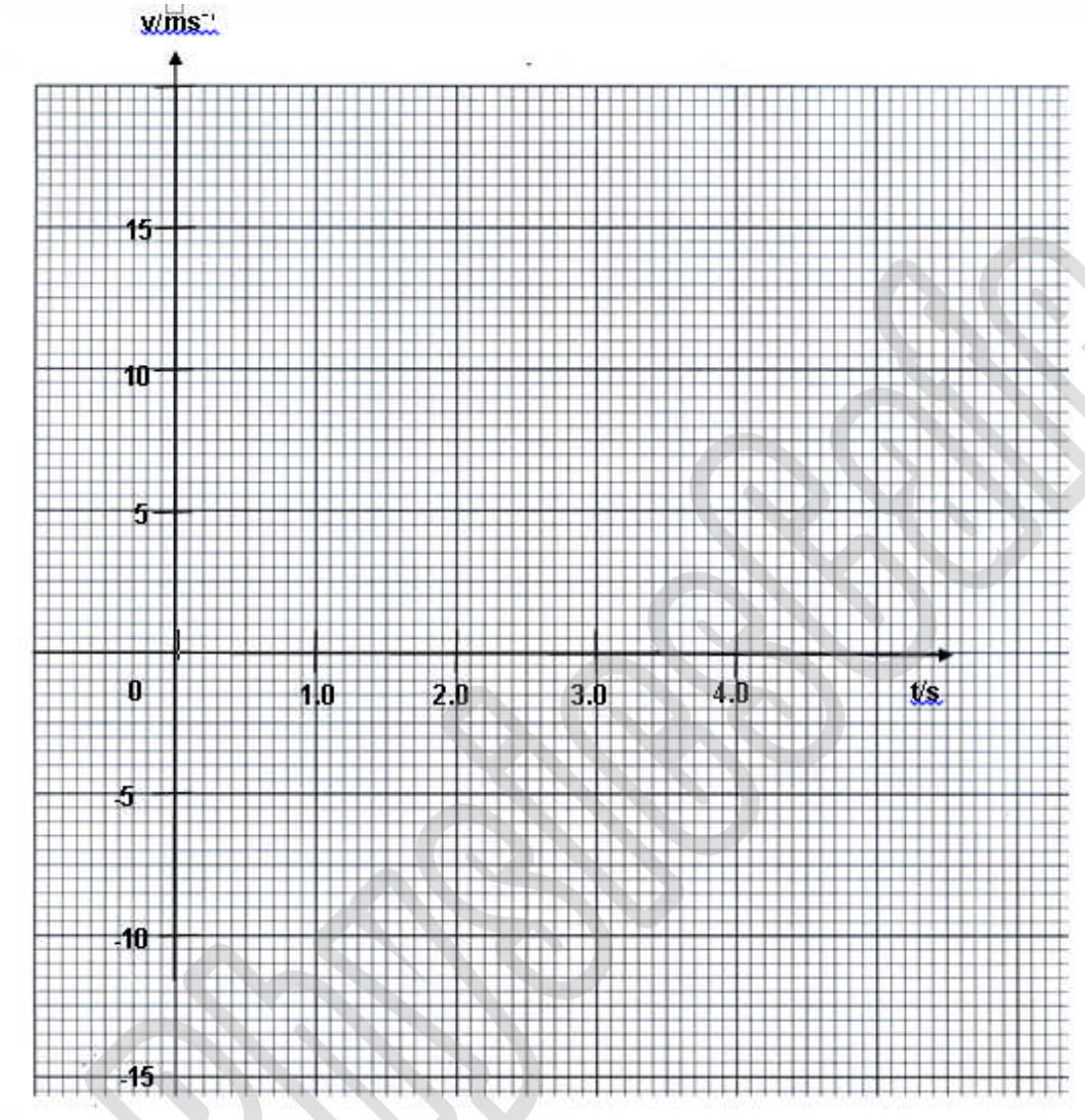


Fig. 2.2

[1]

(e) If air resistance is significant, sketch the variation of the vertical component of the velocity with time on Fig. 2.2. Label it as **B**. . **[2]**

Ans

(a) Using $v_y = u_y + a_y t$: **M1**
At max height, $v_y = 0$.
$0 = 30 \sin 30^o - (9.81)\, t$
$t = 1.529$ s **A1**
time taken = 1.529 x 2 = 3.06s

(b) Range = $u_x t = 30 \cos 30° \,(3.06) = 79.5$ m **A1**

(c) 60° **A1**

(d) A straight line starting at 15 ms^{-1} to -15 ms^{-1} cutting through t = 1.529 s at the midway when v = 0 **B1**

(e) Key features to note: time taken upwards < time taken downwards **B1**
gradient at x-intercept is still acceleration at free fall **B1**

3 A stuntman on a motorcycle plans to ride up a ramp in order to jump over a number of cars as shown in Fig. 1.

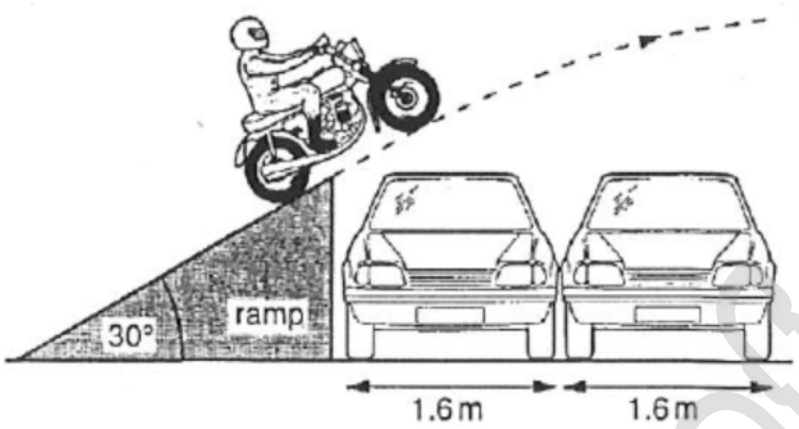


Fig. 1

His velocity is **14 m s^{-1}** as he leaves the ramp at t = 0 s. Assume that air resistance is negligible throughout the question.

(a) Suggest why the ramp cannot be frictionless in order for him to travel up the ramp.

.....

.....

.....

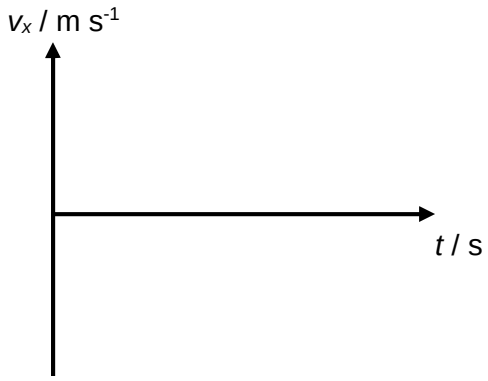
..... [1]

(b) The cars are each of width **1.6 m** and the same height as the ramp. Estimate the maximum number of cars which he can jump over.

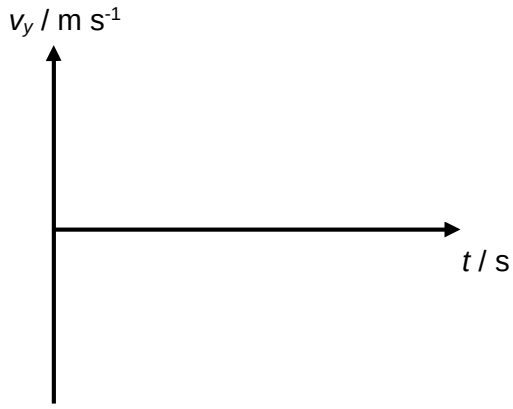
maximum number of cars = ... [3]

(c) On the axes below, sketch the variation with time t during his flight in air for

(i) the horizontal component of his velocity, $v_{x,}$ [1]



(ii) the vertical component of his velocity, v_y [1]



Ans **(a)** The ramp cannot be frictionless so that the **ramp can exert** a **forward force on the driving wheel (s) to accelerate up the ramp** to overcome the gravitational force of the stuntman. **[1]**

(b) When he takes off and reaches the same height as the car, $s_y = 0$ m

$$s_y = u_y t + \frac{1}{2}at^2$$

$$0 = \left(14\sin 30^o + \frac{1}{2}(-9.81)t\right)t$$ [1] – t

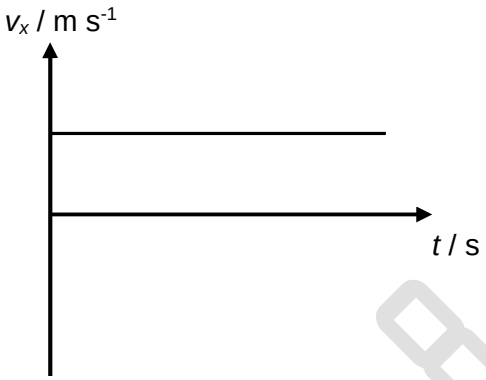
$t = 0$ s OR 1.427 s

Let x = number of cars that can jump over

$$1.6x = (14\cos 30^o)(1.427) = 17.3$$ [1] – subs

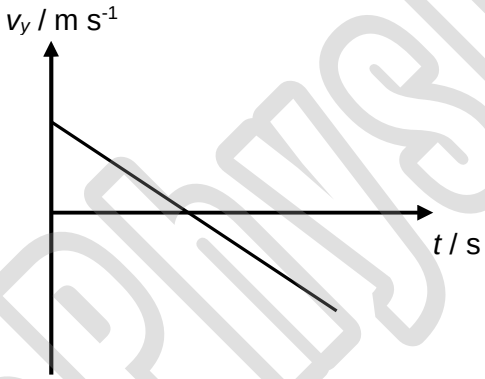
$$x = 10.8 = 10$$ [1] – Ans

(c)(i)



[1]

(c)(ii)



[1]