

HOLIDAY HOMEWORK 1: MOTION, VECTORS, FREEFALLING AND GALILEAN RELATIVITY

Complete on a separate piece of paper and submit the working and your answers first week back

Email if you have any questions with the question number and your issue

1. a)

$$\begin{aligned}
 t &= 5s \\
 s &= 2.5t^2 \\
 \Rightarrow s &= 62.5 \text{ m} \\
 \text{average speed} &= \frac{\text{total distance travelled}}{\text{total time taken}} = \frac{62.5}{5} = 12.5 \text{ ms}^{-1}
 \end{aligned}$$

b)

$$\begin{aligned}
 \text{Instantaneous velocity: } s &= \frac{1}{2}(u + v)t \Rightarrow v = \frac{2s - u}{t} \\
 u &= 0 (\text{substitute } t = 0 \text{ into the equation for } s) \\
 t &= 5s \\
 s &= 62.5 \text{ m} \\
 v &= \frac{62.5 \times 2}{5} = 25 \text{ ms}^{-1}
 \end{aligned}$$

2. a)

$$\begin{aligned}
 s &= u_f t + \frac{1}{2} a t^2 \\
 \text{where } u_f &\text{ is the speed of the particle just before the last 1 second}
 \end{aligned}$$

b)

$$\begin{aligned}
 \text{In this question } u_f &= 5 \\
 a &= 2 \text{ in/s}^2 = 0.051 \text{ m/s}^2 \\
 t &= 10 \text{ s} \\
 s &= 5 \times 10 + \frac{1}{2} \times 0.051 \times 100 = 52.55 \text{ m}
 \end{aligned}$$

3. Time taken to walk first 1km = $\frac{1}{6}$

Time taken to walk second 1km = $\frac{1}{8}$

Total time taken to cover the 2km = $\frac{1}{6} + \frac{1}{8} = \frac{7}{24}$ hour

Average speed = $\frac{\frac{2}{7}}{\frac{7}{24}} = \frac{48}{7} = 6.86 \frac{\text{km}}{\text{hr}} = 1.9 \text{ ms}^{-1}$

4. Total distance covered = 40 ft x 10 = 121.92 m x 10 = 1219.2 m

Time taken to walk the distance = 50 mins

Average speed = $\frac{\frac{121.92}{50} \text{ m}}{\text{min}} = \frac{\frac{121.92}{3000} \text{ m}}{\text{s}} = 0.041 \text{ ms}^{-1}$

Average velocity = 0 since the displacement is = 0

5. a) $a = \frac{\Delta v}{\Delta t} = \frac{150-100}{1} = 50ms^{-2}$

b) $s = ut + \frac{1}{2}at^2$
 $\Rightarrow 100 \times 1 + \frac{1}{2} \times 50 \times 1^2 = 125m$

6. $s = ut + \frac{1}{2}at^2$
 $\Rightarrow 0.24 = 0 + \frac{1}{2} \times a \times 2.2^2$
 $\Rightarrow a = \frac{0.24 \times 2}{2.2^2} = 0.0992ms^{-2}$

7. The pickpocket will be caught if the velocity of the pickpocket v_p is smaller than or equal to v , mathematically this is represented as:

$$v \geq v_p$$

$$v_p^2 = u_p^2 + 2as$$

$u_p = 0$ since the motorcycle is stationary to begin with

let $s = d$ since we are trying to determine if the pickpocket will be caught

$$v_p^2 = 2ad$$

$$v_p = \sqrt{2ad}$$

Substituting the value of v_p into the first equation:

$$v \geq \sqrt{2ad}$$

8. Equation of motion of the car: $s_{car} = 4000 - 11.11t$

Equation of motion of the fly: $s_{fly} = 27.78t$

9. Solution in the hand-written solutions

10.

$$v^2 = u^2 + 2as$$

$$u = 0, a = 10, s = 50$$

$$v^2 = 2 \times 10 \times 50 = 1000$$

$$v = 31.62 ms^{-1}$$

11. Solution in the hand-written solutions

12. Solution in the hand-written solutions

13. Solution in the hand-written solutions

14. $10 ms^{-2}$ down

15.

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

$$t = 5, a = P2, u = 4$$

$$s = 20 + \frac{25P2}{2} m$$

16.

$$v^2 = u^2 + 2as$$

$$u = 43.2 \frac{km}{h} = 12 \frac{m}{s}, a = -6ms^{-2}, v = 0$$

$$0 = 144 - 12s$$

$$s = 12m$$

17. Solution in the hand-written solutions

18.

$$v^2 = u^2 + 2as$$

$$u = 16, v = 0, s = 0.4$$

$$0 = 256 + 0.8a$$

$$a = -320ms^{-2}$$

$$v = u + at$$

$$v = 0, u = 16, a = -320$$

$$0 = 16 - 320t$$

$$t = 0.05s$$

19. a) average velocity: $18/5 = 3.6 \text{ km/h}$

b)

$$v^2 = u^2 + 2as$$

$$u = 0, v = 3.6$$

$$as = 6.48$$

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

$$u = 0, t = 5$$

$$s = 12.5a$$

$$a = \frac{2s}{25}$$

substituting the value of a:

$$\frac{2s^2}{25} = 6.48$$

$$s^2 = 81$$

$$s = 9m$$

20.

$$v^2 = u^2 + 2as$$

$$u = \frac{54km}{hr} = \frac{15m}{s}, a = -6, v = 0$$

$$0 = 225 - 12s$$

$$s = 18.75m$$

21. Speed of the Motorcycle = 72km/hr = 20m/s

Speed of the Jeep = 90km/hr = 25m/s

Distance between the Jeep and the bike = 20 x 10 = 200m

Speed of the Jeep in the reference frame of the Motorcycle = 25 – 20 = 5

Time taken for the Jeep to catch up to the Bike = 200/5 = 40 seconds

22.

$$\begin{aligned}v^2 &= u^2 - 2gh \\v &= 0, u = 50, g = 10 \\20h &= 2500 \\h &= 125m\end{aligned}$$

23.

$$\begin{aligned}s &= ut + \frac{1}{2}gt^2 \\125 &= 5t^2 \\t &= 5s\end{aligned}$$

24. a)

$$\begin{aligned}v^2 &= u^2 - 2gh \\v &= 0, u = 28, g = -10 \\0 &= 784 - 20h \\h &= 39.2m\end{aligned}$$

b)

$$\begin{aligned}v &= u + gt \\v &= 0, u = 28, g = -10 \\0 &= 28 - 10t \\t &= 2.8s\end{aligned}$$

$$\begin{aligned}v &= u + gt \\u &= 28, t = 1.8, g = -10 \\v &= 28 - 18 \\v &= 10ms^{-1}\end{aligned}$$

c)

$$\begin{aligned}v &= u + gt \\v &= 0, u = 40, g = -10 \\0 &= 40 - 10t \\t &= 4\end{aligned}$$

$$\begin{aligned}v &= u + gt \\u &= 40, g = -10, t = 3 \\v &= 40 - 30 \\v &= 10ms^{-1}\end{aligned}$$

Thus the answer doesn't change even if the initial speed changes

25. Solution in the hand-written solutions

26. Solution in the hand-written solutions

27. Same question as 24

28.

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

$$u = 0, t = 3, g = 10$$

$$s_{3rd\ ball} = 45m\ from\ the\ top\ of\ the\ building$$

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

$$u = 0, t = 2, g = 10$$

$$s_{4th\ ball} = 20m\ from\ the\ top\ of\ the\ building$$

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

$$u = 0, t = 1, g = 10$$

$$s_{5th\ ball} = 5m\ from\ the\ top\ of\ the\ building$$

$$s_{6th\ ball} = \text{still at the top of the building}$$

29. The man wants to catch the child at a height of 10m

The time taken for the child to fall this height:

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

$$s = 10m, u = 0, g = 10$$

$$10 = 5t^2$$

$$t = 1.414s$$

The distance the man has to cover in this time:

$$v = \frac{s}{t}$$

$$s = 7, t = 1.414$$

$$v = \frac{7}{1.414} = 4.95ms^{-1}$$

30. The stone is 6ft above the floor = 1.83 m above the ground

Acceleration of the stone:

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

$$s = 1.83, u = 0, t = 1$$

$$1.83 = \frac{1}{2}a$$

$$a = 3.66 \text{ ms}^{-2}$$

This acceleration is in the frame of the stone if the elevator is still if the elevator is moving:

$$a = a_{\text{elevator}} - g$$

$$3.66 = a_{\text{elevator}} - 10$$

$$a_{\text{elevator}} = 13.66 \text{ ms}^{-2}$$

31. Solution in the hand-written solutions

32. a)

$$\text{displacement of the minute hand} = \frac{2\pi r}{2} = \pi \times 0.04 = 0.126 \text{ m}$$

$$\text{time taken to cover this distance} = 30 \text{ mins} = 1800 \text{ seconds}$$

$$\text{Average velocity of the minute hand} = 6.98 \times 10^{-5} \text{ ms}^{-1}$$

b)

$$\text{displacement of the minute hand} = 0.126 \text{ m}$$

$$\text{time taken to cover this distance} = 750 \text{ mins} = 45000 \text{ seconds}$$

$$\text{Average velocity of the minute hand} = 1.55 \times 10^{-9} \text{ ms}^{-1}$$

33. a)

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

$$s = 2.5 \times 2 + 0.5 \times 2$$

$$s = 6 \text{ m}$$

b)

$$v = u + at$$

$$v = 7.5, u = 2.5, a = 0.5$$

$$7.5 = 2.5 + 0.5t$$

$$0.5t = 5$$

$$t = 10 \text{ s}$$

c)

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

$$u = 2.5, a = 0.5, t = 10$$

$$s = 2.5 \times 10 + \frac{1}{2} \times 0.5 \times 100$$

$$s = 50 \text{ m}$$

34. Speed of the ball = $4 \text{ in/s} = 0.1016 \text{ m/s}$

$$v^2 = u^2 - 2gh$$

$$u = 0.1016, g = 10, v = 0$$

$$0 = 0.4064 - 20h$$

$$h = 0.02032m$$

35. Solution in the hand-written solutions

36. Same question as 8

37. Same question as 9

38. Time taken for the stone to hit the ground:

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

$$s = 50, u = 0, a = 10$$

$$50 = 5t^2$$

$$t = 3.16s$$

The distance the balloon would have travelled at this point:

$$s = ut = 5 \times 3.16 = 15.81$$

Total height of the balloon = distance travelled + initial height

$$\text{Total height} = 65.81m$$

39. Solution in the hand-written solutions

40. Solution in the hand-written solutions

41. Solution in the hand-written solutions

42. Solution in the hand-written solutions

43. Solution in the hand-written solutions

44. It is not a question

45. a) $10ms^{-1}$ away from you

b) $10ms^{-1}$ away from the car

c) It is never going to catch up

46. Solution in the hand-written solutions

47. Because it is moving away from you in your plane of sight, therefore it appears stationary when it is in fact moving away from you.

48. Solution in the hand-written solutions

49.

$$v^2 = u^2 + 2as$$

$$u = 0, a = 10, s = 1700$$

$$v^2 = 2 \times 10 \times 1700$$

$$v = 184.39 ms^{-1}$$

50.

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

$$s = 36.8, a = -10, t = 2.25$$

$$36.8 = 2.25u - 25.3125$$

$$u = 27.61ms^{-1}$$