THE COPPERBELT UNIVERSITY
SCHOOL OF MATHEMATICS AND NATURAL SCIENCES
DEPARTMENT OF PHYSICS

PH 110 INTRODUCTORY PHYSICS

TUTORIALSHEET 3: Kinematics_2023/2024

1. A toy boat moves horizontally in a pond. The displacement–time graph of the boat is shown in **Figure 1**. Find the **average velocity** and the **average speed** in the time intervals:
   (a) 0 to 8 s
   (b) 0 to 12 s
   (c) 8 s to 16 s
   (d) 0 to 24 s
   (e) 12 to 24 s

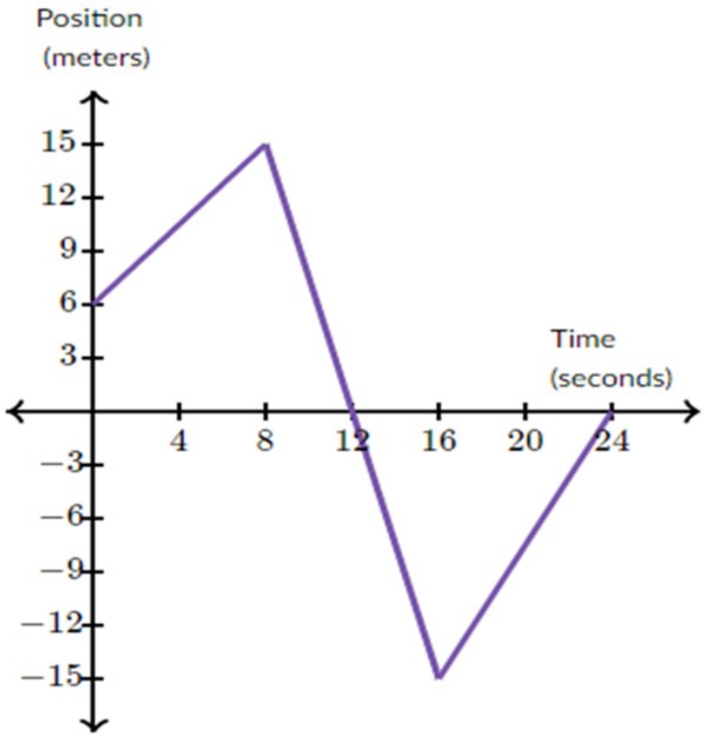


Figure 1

2. Two trains, one travelling at 72 km/h and the other one at 144 km/h, are headed toward one another along a straight level track. When they are 950 m apart, each engineer sees the other's train and applies breaks. If the breaks decelerate each train at the rate of $1 m/s^2$, is there a collision?

3. A car travels 1 km between two stops. It starts from rest and accelerates at 2.5 m/s^2 until it attains a velocity of 12.5 m/s. The car continues at this velocity for some time and decelerates at 3 m/s^2 until it stops. Calculate the total time for the journey.

4. A motorcycle policewoman hidden at an intersection observes a car that ignores a stop sign, crosses the intersection, and continues on at constant speed of 72 km/h. 2 seconds after the car crosses the intersection, the policewoman starts off in pursuit, accelerating uniformly at 3 m/s^2 until she catches the car.
   (a) How long does it take the motorcycle to catch up with the car?
   (b) How far will the car move when this happens?

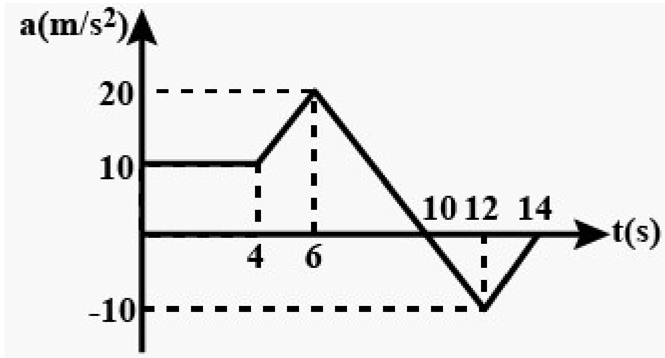
5. Two parallel rail tracks run north-south. Train A moves north with a speed of 54 km/h and train B moves south with a speed of 90 km/h. What is the relative velocity in m/s of
   (a) B with respect to A
   (b) the ground with respect to B
   (c) a monkey running on the roof of train A against its motion (with velocity 18 km/h with respect to A) as observed by a man standing on the ground.

6. A ball is thrown upward and reaches height of 4 meters. Find the initial speed and time taken by ball to come to the thrower (g=10).

7. A Bullet is fired from a rifle with a velocity 750m/s. If length of rifle barrel is 50cm, calculate average velocity of the bullet, while being accelerate in barrel. Find the time taken by the bullet to travel.

8. A projectile is fired from the top of a cliff of height h above the ocean below. If it was fired at an angle θ above the horizontal with an initial speed v_o.
   i) Find a symbolic expression in term of the variables v_o, g and θ for the time at which the projectile reaches its maximum height.
   ii) Using the result in part (i), find an expression for the maximum height above the ocean attained by the projectile in terms of h, v_o, g and θ.

9. Acceleration-time graph of a particle moving in a straight line is as shown in **Figure 2** At time $t = 0$ velocity of the particle is zero. Find the average acceleration in a time interval from $t = 6s$ to $t = 12s$.



10. A projectile is fired with an initial speed of 113 m/s at an angle of 60 ° above the horizontal from the top of a cliff 49 m high.

Find:
(a) the time to reach the maximum height,
(b) the maximum height,
(c) the total time in the air,
(d) the horizontal range and
(e) the components of the final velocity just before the projectile hits the ground.

11. Two stones are dropped from the edge of a 60m cliff, the second stone 1.6s after the first. How far below the top of the cliff is the second stone when the separation between the two stones is 36m?

12. Just as a car starts to accelerate from rest at a constant acceleration of $2.44 m/s^2$, a bus moving at a constant speed of 19.6m/s passes the car in a parallel lane.
a) How long does it take the car to overtake the bus?
b) How fast is the car moving?
c) How far has the car gone at that point?

13. A ball thrown from the top of a 50m tall building is given an initial velocity of 20m/s straight upwards. The ball just misses the edge of the roof on its way down.
a) Determine the time at which the ball reaches its maximum height.
b) Determine the maximum height.
c) The time at which the ball returns to the height from which it was thrown.
d) The velocity of the ball at this instant.

e) The velocity and position of the ball at $t = 5$s.

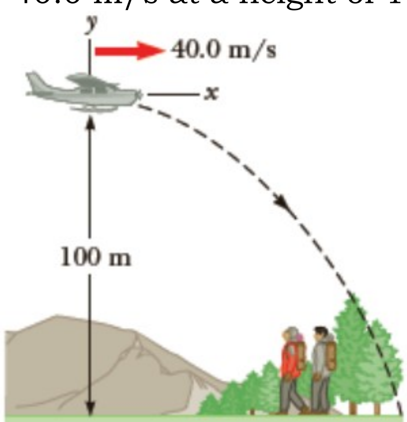
14. A stone is released from a hot- air balloon which is rising steadily at 4m/s. Find the velocity of the stone after 3 s of release.

15. A stone is dropped by a person from the top of a building, which is 200 m tall. At the same time, another stone is thrown upwards, with a velocity of 50 m/s by a person standing at the foot of the building. Find the time after which the two stones meet.

16. Show that time of ascent of an object thrown vertically upwards is equal the time of its descent.

17. A bullet is fired from the ground vertically upwards with an initial velocity of 100 m/s.
    (i) Find the total time of flight.
    (ii) Find the total distance covered by the bullet.
    (iii) What is the bullet's velocity on the ground?
    (iv) What are the assumptions made in these calculations?

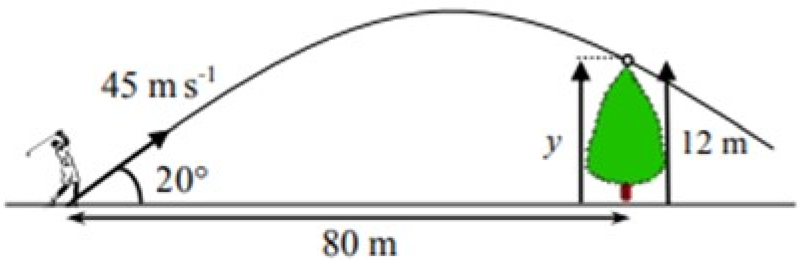
18. An Alaskan rescue plane drops a package of emergency rations to stranded hikers, as shown in the Figure below. The plane is traveling horizontally at 40.0 m/s at a height of 1.0x 10^2 m above the ground. Neglect air resistance.



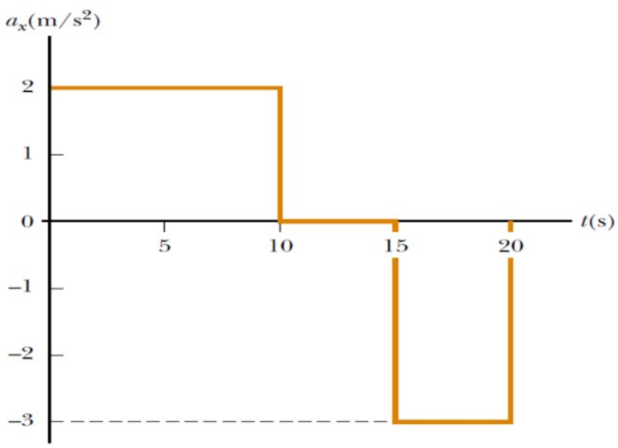
a) Where does the package strike the ground relative to the point at which it was released?
b) What are the horizontal and vertical components of the velocity of the package just before it hits the ground?
c) What is the angle of the impact?

19. A ball of mass 200 g covers a maximum vertical distance of 10 m when it is kicked at an angle of 30° from the horizontal ground.
(a) How long will the ball be in the air?
(b) How far from the point of projection will the ball land?

20. If the golf ball is hit in the direction of a 12-meter tree which is 80 meters from the golfer, will the ball pass over the tree or hit it? See the figure below (Not drawn to scale)



21. A particle starts from rest and accelerates as shown in the figure below.
   (a) Find the particle's speed at t = 10 s and at t = 20 s.
   (b) Draw the velocity-time graph for a particle in the interval from t=0 to t=20s.
   (c) Determine the distance traveled in the first 20 seconds.



Q1 2023/2024 Tuturial 3

average speed = $\frac{\text{total distance}}{\text{time taken}}$

average velocity = $\frac{\text{displacement}}{\text{time}}$

(a) distance = 15 − 6
= 9m

displacement = 15 − 6
= 9m

$S = \frac{9}{8}$

$S = \frac{9}{8} m/s$

$\bar{v} = \frac{9}{8}$

$\bar{v} = \frac{9}{8} m/s$

(b)(i) distance $= 9 + 15 + 0 = 24m$

$S = \frac{24m}{12s} = 2m/s$

(ii) displacement $= 0 - 6 = -6m$

$\bar{v} = -\frac{6m}{12s} = -0.5 m/s$

(c)(i) distance $= 15 + 15 = 30m$

$\therefore S = \frac{30m}{8s} = 3.75 m/s$

(ii) displacement $= -15 - 15 = -30m$

$\bar{v} = \frac{-30m}{8s} = -3.75 m/s$

(d) distance $= (15-6) + 15 + 15 + (0+15)$
$= 54m$

$s = \frac{54m}{24s} = \underline{\underline{2.25 m/s}}$

(ii) displacement $= 0 - 6 = -6m$

$\therefore \bar{v} = -\frac{6m}{24s} = \underline{\underline{-0.25 m/s}}$

(e) distance $= 15 + 15 = 30m$
$s = \frac{30m}{24s} = \underline{\underline{1.25 m/s}}$

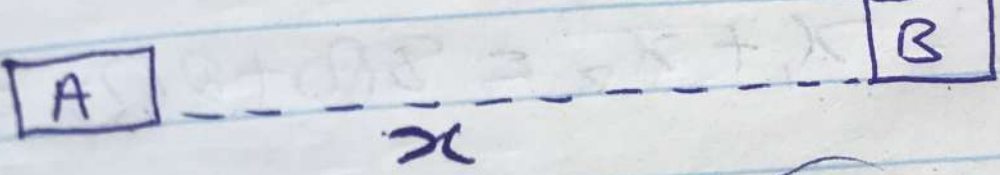
displacement $= 0m$
$\bar{v} = \frac{0m}{24s} = \underline{\underline{0 m/s}}$

first Convert Km/h to m/s

Q2 72 Km/h = 20m/s & 144Km/h = 40m/s

they both have $a = 1 m/s^2$

We ne to be carefull of the signs



let train A be moving at 40m/s and train B at -20m/s and x is the distance between them.

for train A

$v = 0 m/s$, $u = 40 m/s$, $a = -1 m/s$

$x = ?$

$v^2 = u^2 + 2ax$

$(0)^2 = (40)^2 + 2(-1)x$

$x_1 = 800 m$

Ans

for train B

$v = 0 m/s$ $u = -20 m/s$ $a = 1 m/s$ $x = ?$

$v^2 = u^2 + 2ax$

$(0)^2 = (-20)^2 + 2(1)x$

$x_2 = +200 m$

Ans

$x_1 + x_2 < 950m$ (No collision)

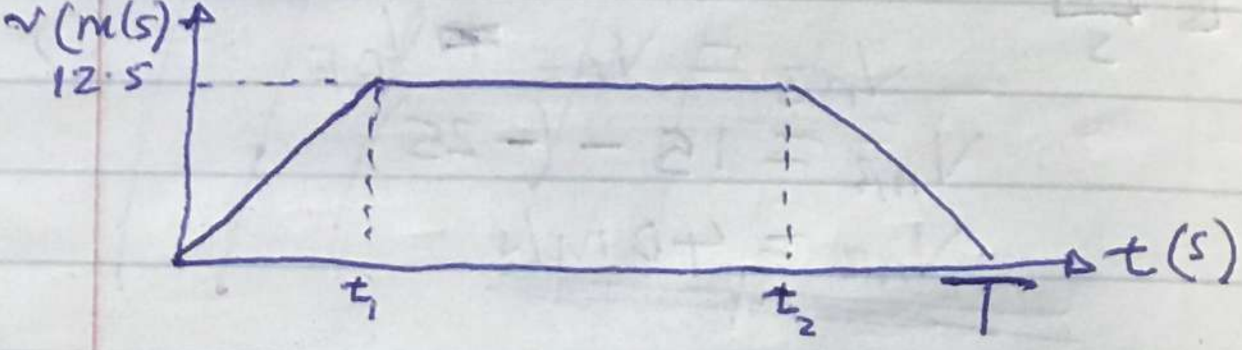
$x_1 + x_2 > 950m$ (collision)

$\therefore x_1 + x_2 = 800 + 200 = 1000m$

$\therefore 1000m > 950m$

then their will be a collision

Q3 lets use the Graph to Interpret the motion



We have the $a = 2{\cdot}5\,m/s^2$ and $a = -3\,m/s^2$ the total distance is 1000m and the Velocity time graph is equal to Area, whereas area is the distance then;

For t_1

$A = \frac{1}{2} bh$

$x_1 = \frac{1}{2} v t_1$ —(i)

and $a = \frac{v-u}{t}$

$2{\cdot}5 = \frac{12{\cdot}5 - 0}{t_1}$

$t_1 = 5\,sec$

$\therefore x = \frac{1}{2} v t_1$

$x_1 = \frac{1}{2} \times 12.5 \times 5$

$x_1 = 31.25 m$ for first t_1

for t_2

$x_2 = \frac{1}{2} u t_2$ — (i)

$a = \frac{v-u}{t_2} \Rightarrow -3 = \frac{0 - 12.5}{t_2}$

$\therefore t_2 = 4.17 s$

$\therefore x_2 = \frac{1}{2} \times 12.5 \times 4.17$

$x_2 = 26.04 m$

lets find the distance between t_1 and t_2, since we know the total distance

$x = x_1 + x_2 + x_3$ — (iii)

where x is the total distance and x_3 is the distance between t_1 & t_2

$\therefore 1000 = 31.25 + 26.04 + x_3$

$\therefore x_3 = 942.71 m$

then let find its time say t_3.
t_3 is the time between t_2 & t_1

$\therefore x_3 = vt_3$ —(iv)

$942.74 = 12.5 t_3$

$\therefore \underline{\underline{t_3 = 75.42 \text{ sec}}}$

$\therefore T = t_1 + t_2 + t_3$

$\therefore T = 5 + 4.17 + 75.42$

$\underline{\underline{T = 84.59 \text{ sec}}}$

Is the total time taken.

Q4 first convert 72km/h to 20m/s

~~Motorcycle~~ ~~car~~

$V_0 = 20m/s$ $u = 0m/s$

$x_0 = 40m$ $a = 3m/s^2$

$x_c = x_0 + V_0 t$ $x_m = x_0 + \frac{1}{2}at^2$

(a) at a point a motorcycle catches the car $x_c = x_m$

$40 + 20t = \frac{1}{2}(3)t^2$

$3t^2 - 40t - 80 = 0$

$t = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$

$t = \frac{-(-40) \pm \sqrt{(40)^2 - 4(3)(-80)}}{2(3)}$

$t = \frac{40 \pm \sqrt{2560}}{6}$

$t = \frac{40 \pm 50.6}{6}$

$t = \frac{90.6}{6}$

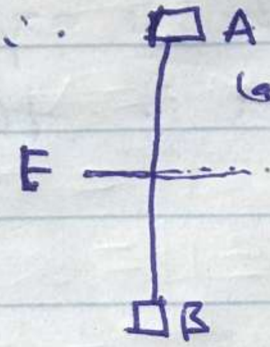
$t = 15.1 \text{ sec}$

(b) $x_c = 40 + 20(15.1)$

$x_c = 341.9m$

Q5 Convert km/h to m/s

54 km/h $\simeq$ 15 m/s   90 km/h $\simeq$ 25 m/s



(a) $V_{BA} = V_B - V_A$

$V_{BA} = -25 - 15$

$V_{BA} = -40\,m/s$

(b) $V_{gB} = V_B$

$V_{gB} = -25\,m/s$

$V_{gB} = V_g - V_B$

$V_{gB} = 0 - (-25)$

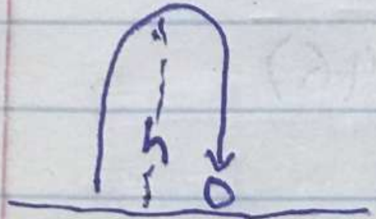
$V_{gB} = 25\,m/s$

$V_{mg} = V_{mA} + V_{Ag}$

$V_{mg} = 5m/s - 15m/s$

$V_{mg} = -10m/s$ North

Q6



$h = 4m \quad a = -g \quad u = ? \quad t = ?$

$V = 0 m/s$ (Peak)

(a) $v^2 = u^2 + 2ay$

$(0)^2 = u^2 + 2(-10)(4)$

$\sqrt{u^2} = \sqrt{80}$

$u = 4\sqrt{5}$ m/s $= 8.94$ m/s

(b) $y = 0m \quad a = -g \quad u = 4\sqrt{5}$ m/s

$y = ut + \frac{1}{2} g t^2$

$0 = 4\sqrt{5}t - 5t^2$

$t(4\sqrt{5} - 5t) = 0$

$t = 0$ or $4\sqrt{5} - 5t = 0$

$5t = 4\sqrt{5}$

$\therefore t = \frac{4\sqrt{5}}{5}$

$\therefore t = 1.79 \, sec$

Q7 $\bar{v} = \frac{v+u}{2}$

$\bar{v} = \frac{0+750}{2}$

$\bar{v} = 375 \, m/s$

(ii) $\cancel{v = u + at}$ $x = 50cm = 50 \times 10^{-2} m$

$\cancel{0 = 750}$.

$\cancel{x = ut + \frac{1}{2}at^2}$ —(i) $v = u + at$

$\cancel{0 = 750 +}$

$x = 50 \times 10^{-2} m$, $u = 750 \, m/s$

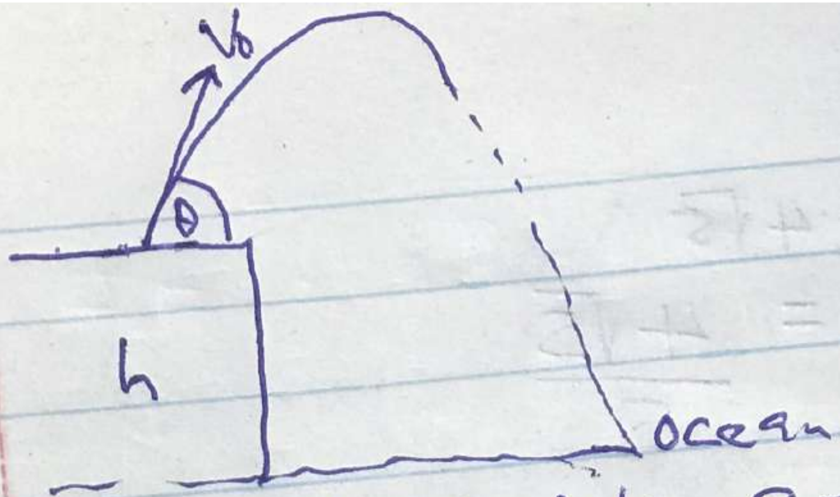
$v^2 = u^2 + 2ax$

$(0)^2 = (750)^2 + 2(0.050)a$

$a = 5625000 \, m/s^2$

$\therefore a = \frac{v-u}{t}$ $\therefore t = 0.000133 \, sec$

Q8



(i) at Peak $V_y = 0\,m/s$ $\quad a = -g$

$Y_f = Y_0 + V_{0y}\sin\theta\, t + \frac{1}{2} a t^2$ --- (i)

$V_y = V_0 \sin\theta \cancel{+} at$ --- (ii)

using eqn (ii)

$0 = V_0 \sin\theta - gt$

$V_0 \sin\theta = gt$

$\therefore\ t = \dfrac{V_0 \sin\theta}{g}$

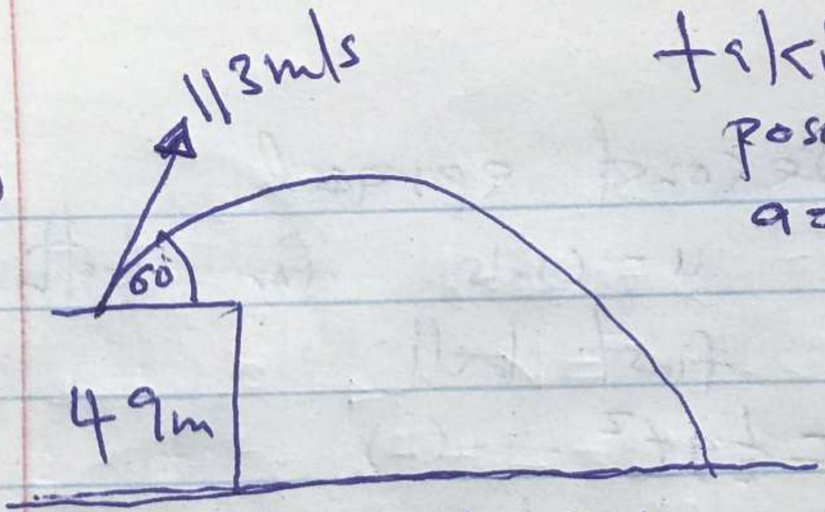
(ii) from eqn (i)

$Y = h + V_0 \sin\theta \left(\dfrac{V_0 \sin\theta}{g}\right) - \dfrac{1}{2} g \left(\dfrac{V_0 \sin\theta}{g}\right)^2$

$Y = h + \dfrac{V_0^2 \sin^2\theta}{g} - \dfrac{1}{2}\dfrac{V_0^2 \sin^2\theta}{g}$

$\therefore\ Y = h + \dfrac{1}{2}\dfrac{V_0^2 \sin^2\theta}{g}$

Q10



taking upward as positive.
$a = -g$

(a) $Y_{max} = h$, $V_y = 0 m/s$ $g = -9.8 m/s^2$

$V_{oy} = 113 \sin 60 = 97.861 m/s$

$\therefore V_y = V_{oy} + at$

$0 = 97.861 - 9.8t$

$9.8t = 97.861$

$t = 9.986$ sec

Ans

(b) $Y_{max} = Y_o + V_{oy}t + \frac{1}{2}at^2$

$h = 0 + 97.861(9.986) - 4.9(9.986)^2$

$h = 977.221 - 488.6097$

$h = 488.611m + 49m = 537.611m$

Ans

(c) $Y = Y_o + V_{oy}t + \frac{1}{2}gt^2$

$-49 = 0 + 97.861t - 4.9t^2$

$4.9t^2 - 97.861t - 49 = 0$

$\therefore t = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$

$= \frac{97.861 \pm \sqrt{(97.861)^2 - 4(4.9)(-49)}}{9.8}$

$$\frac{97.861 \pm \sqrt{10537.15}}{9.8} = t$$

$$t = \frac{97.861 \pm 102.65064}{9.8}$$

$$t = \frac{200.51164}{9.8}$$

$$\underline{t = 20.46 \text{ sec}}$$

(d) $x = V_{ox} \cos\theta \, t$

$x = 113 \cos 60 (20.46)$

$\underline{x = 1156.011 m}$

(e) $V_x = V_{ox}$ $\quad$ $V_y = V_{oy} - gt$

$\therefore \underline{V_x = 56.5 m/s}$ $\quad$ $V_y = 97.861 - 9.8(20.48)$

$V_y = 97.861 - 200.808$

$\underline{V_y = -102.947 m/s}$

Q9

The area under the accelaration time graph is speed (velocity) lets solve for velocity at $t = 6s$ and $t = 12$ sec

at $t = 6s$

$V_1 = 10 \times 4 + \frac{1}{2} \times 2 \times 10 + 10 \times 2$

$V_1 = 40 + 10 + 20$

$V_1 = 70 m/s$

at $t = 12$ sec

$V_2 = V_1 + \frac{1}{2} \times 4 \times 20 + \frac{1}{2} \times 2 \times (-10)$

$V_2 = 70 + 40 - 10$

$V_2 = 100 m/s$

$\therefore \bar{a} = \frac{V_2 - V_1}{t}$

$\bar{a} = \frac{100 - 70}{6}$

$\bar{a} = 5 m/s^2$

Or second approach

$a = g \quad u = 0\,m/s$ for both.

for the first ball

$60 - Y = \frac{1}{2} g t^2$ ---- (i)

for the second one

$60 - Y - 36 = \frac{1}{2} g (t - 1.6)^2$ --- (ii)

Combine eqn (i) and (ii)

$$\frac{1}{2} g t^2 - 32 = \frac{1}{2} g (t - 1.6)^2$$

$$\frac{1}{2} g t^2 - 36 = \frac{1}{2} g (t^2 - 3.2t + 2.56)$$

$$\frac{1}{2} g t^2 - 36 = \frac{1}{2} g t^2 - 15.68t + 12.544$$

$$-36 = -15.68t + 12.544$$

$$-48.544 = -15.68t$$

$$\therefore t = 3.096\,sec$$

taking eqn (ii) $60 - Y - 36 = \frac{1}{2} g (t - 1.6)^2$

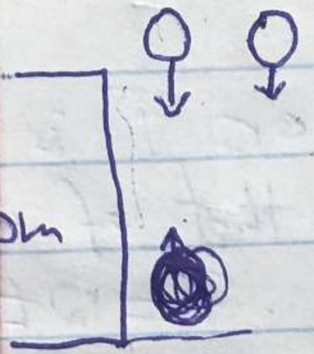
taking $t = 3.096$

$$Y + \cancel{24} = 10.9651$$

$$\cancel{Y = 13}$$

$$\therefore Y = 10.9651\,m$$

Q11



For Descending stage

take $a = g$ $u = 0\,m/s$

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

$Y_1 = \frac{1}{2}gt^2$ —— (i)

The second ball

$a = g$ $u = 0\,m/s$

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

$Y_2 = \frac{1}{2}g(t - 1.6)^2$ —— (ii)

$Y_1 - Y_2 = 36$

$\frac{1}{2}gt^2 - \frac{1}{2}g(t - 1.6)^2 = 36$

$\frac{1}{2}gt^2 - \frac{1}{2}g(t^2 - 3.2t + 2.56) = 36$

$\frac{1}{2}gt^2 - \frac{1}{2}gt^2 + \frac{1}{2}g(3.2)t - \frac{1}{2}g(2.56) = 36$

$15.68t - 12.544 = 36$

$15.68t = 48.544$

$t = 3.096\ sec$

taking eqn (ii)

$Y_2 = 4.9(3.096 - 1.6)^2$

$Y_2 = 10.97m$

Q12 Car

$u = 0 m/s$

$a = 2.44 m/s^2$

$x_c = x_0 + ut + \frac{1}{2}at^2$

bus

$v = 19.6 m$

$x_b = x_0 + ut + \frac{1}{2}at^2$

at a point a car overtakes the bus $x_c = x_b$

$x_c = \frac{1}{2}at^2$ and $x_b = vt$

$\frac{1}{2}at^2 = vt$

$\frac{1}{2}at = v$

$t = \frac{2v}{a}$

$t = \frac{2(19.6)}{2.44}$

$t = 16.1 sec$

(b) $v = u + at$

$v = 0 + 2.44(16.1)$

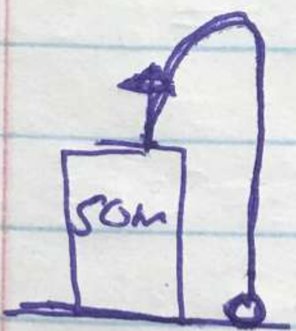
$v = 39.3 \text{ m/s}$

(c) $x_c = \frac{1}{2} a t^2$

$x_c = \frac{1}{2} \times 2.44 \times (16.1)^2$

$x_c = 316.2 \text{m}$

Q13



(a) $a = -g$ $u = 20\,m/s$ $V = 0\,m$

$v = u + at$

$0 = 20 - 9.8t$

$\therefore t = 2.04$ sec

(b) $Y = ut + \frac{1}{2}at^2$ $a = -g$

$Y = 20(2.04) - 4.9(2.04)^2$

$Y = 40.816 - 20.408$

$Y = 20.408\,m$

(c) $Y = 0$ $a = -g$

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

$0 = 20(t) - 4.9t^2$

$t(20 - 4.9t) = 0$

$t = 0$ or $20 - 4.9t = 0$

$4.9t = 20$

$\therefore t = 4.082 sec$

or T is twice that of ascent

$\therefore T = 2t$

$T = 2(2.04)$

$T = 4.082 sec$

(d) $Y = 0$ $a = -g$

$V^2 = u^2 + 2aY$

$\sqrt{V^2} = \sqrt{(20)^2}$

$V = \pm 20 m/s$

we take negative sign

$\therefore V = -20 m/s$

or $V = u + at$

$V = 20 - 9.8(4.082)$

$V = 20 - 40$

$V = -20 m/s$

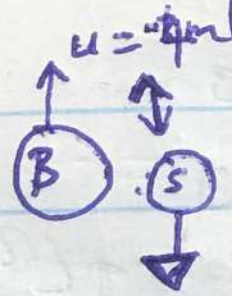
(e) $t = 5 sec$ $u = 20 m/s$ $a = -g$

$V = u + at$

$V = 20 - 9.8(5)$

$V = -29 m/s$

Q 14



$a = g$ taking downward positi

$t = 3s$

$\therefore\ v = u + at$

$v = -4 + 9.8(3)$

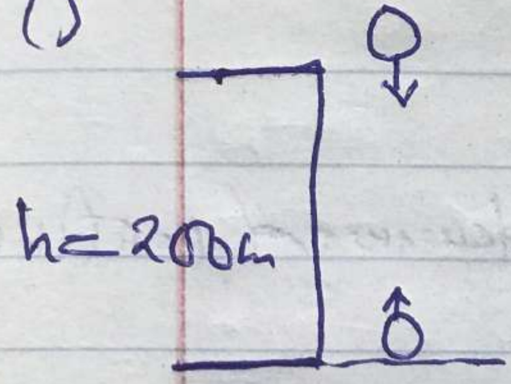
$v = 25.4\ m/s$

Note If You chose downward ne

the answer will be $-25.4\ m/s$

$v = -25.4\ m/s$

Q15



for droping

$u = 0\,m/s \quad a = g$

$\therefore Y = Y_0 + ut + \frac{1}{2}gt^2$

$Y_d = 0 + 0 + \frac{1}{2}gt^2$

$\therefore Y_d = \frac{1}{2}gt^2 \quad \text{---(i)}$

for ascending

$a = -g \quad u = 50\,m/s$

$Y_a = Y_0 \cancel{+} ut + \frac{1}{2}gt^2$

$Y_a = 0 + 50t - \frac{1}{2}gt^2$

$\therefore Y_a = 50t - \frac{1}{2}gt^2 \quad \text{---(ii)}$

$\therefore \quad Y_a + Y_b = 200 \quad \text{---(iii)}$

$50t - \frac{1}{2}gt^2 + \frac{1}{2}gt^2 = 200$

$\frac{50t}{50} = \frac{200}{50}$

$t = 4\ sec$

second method

for droping

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

$200 - x = \frac{1}{2}gt^2 \quad \text{---(i)}$

for ascending

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

$x = 50t - \frac{1}{2}gt^2 \quad \text{---(ii)}$

let x be the meeting place of the two balls

Combine eqn (i) and (ii)

(It for student to finish)

Q16 I will prove it using two methods.

(i) Let start with ascent taking upward as positive (+)

$a = -g \quad v = 0 m/s$ (Peak)

$v = u + at$

$0 = u - gt$

$\frac{gt}{g} = \frac{u}{g}$

$t = \frac{u}{g}$ for Ascending

Now for Descending

let's find the time the object take to move up and return.

$Y = 0 \quad a = -g$

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

$0 = ut - \frac{1}{2}gt^2$

$t(u - \frac{1}{2}gt) = 0$

$t = 0$ (start) or $u - \frac{1}{2}gt = 0$

$2u - gt = 0$

$\frac{gt}{g} = \frac{2u}{g} \quad \therefore t = \frac{2u}{g}$

Since we have calculated for Ascending lets subtract it

$\therefore T_T = T_a + T_d$

where the time of T_d = descending

and T_a = Ascending

$\therefore \frac{2u}{g} = \frac{u}{g} + T_d$

$\frac{2u}{g} - \frac{u}{g} = T_d$

$T_d = \frac{u}{g}$ hence shown.

method 2

for Ascending

at $v = 0\,m/s$ (peak) $a = -g$ $s = h$

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

$(0)^2 = u^2 - 2gh$

$\sqrt{u^2} = \sqrt{2gh}$

$u = \sqrt{2gh}$

$\therefore v = u + at$

$0 = \sqrt{2gh} - gt$ $\therefore t = \frac{\sqrt{2gh}}{g}$

For Desencendly

$u = 0\,m/s$ $a = -g$ $Y = -h$

if you take down ward as negative and $u = 0$ $a = g$ $T = h$ if you take downward as positive

$v^2 = u^2 + 2aY$

$v^2 = (0)^2 + 2(-g)(-h)$

$\sqrt{v^2} = \sqrt{2gh}$

$v = -\sqrt{2gh}$ (remember its $\pm$ we take the negative sign

$\therefore v = u + at$

$-\sqrt{2gh} = 0 - gt$

$t = \frac{\sqrt{2gh}}{g}$ hence shown.

Q17

(i) $u = 100\,m/s \quad V = 0\,m/s$ (peak) $\quad a = -g$

$$a = \frac{v - u}{t}$$

$$-9.8 = \frac{0 - 100}{t}$$

$$t = \frac{100}{9.8}$$

$$\underline{t = 10.204\ sec}$$

(ii) $Y = Y_0 + ut + \frac{1}{2}at^2 \quad a = -g$

$$Y = 0 + 100(10.204) - 4.9(10.204)^2$$

$$Y = 1020.4 - 510.204$$

$$\underline{Y = 510.196\,m}$$

(iii) On the ground $Y = 0\,m$

$\therefore v^2 = u^2 - 2gY$

$$V^2 = u^2$$

$$V^2 - (100)^2 = 0$$

$$(V - 100)(V + 100) = 0$$

$V = 100\,m/s$ or $V = -100\,m/s$

$\therefore V = 100\,m/s \quad V = -100\,m/s$

$\therefore$ On Ground $\underline{V = -100\,m/s}$

Q 18 Let find time first

(a) $Y = ut + \frac{1}{2}at^2$ where $a = +g$

taking downward as positive

$100 = 0 + 4.9t^2$

$\sqrt{t^2} = \sqrt{20.408}$

$t = 4.518 \text{ sec}$

$\therefore x = ut$

$x = 40(4.518)$

$x = 180.702 m$

(b) for x

$V = u + at$

$a = 0$

$V = u$

$\therefore V = 40 m/s$

for y

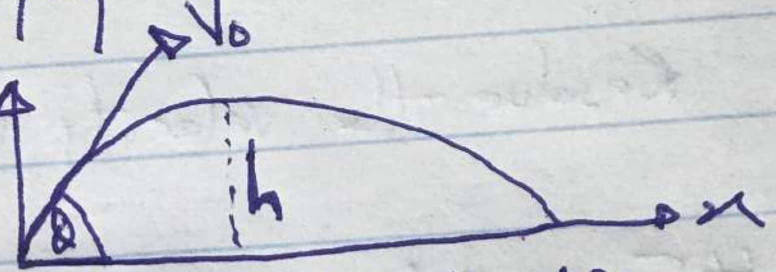
$V = u + at$

$V = 9.8(4.518) + 0$

$V = 44.272 m/s$

(C) $\theta = \tan^{-1}\left(\frac{44.272}{40}\right) = 47.9°$

Q 19



let $\theta = 30°$, $h = 10m$

(a) lets find the initial velocity first from the information given.

at $h = 10m$ $V_y = 0m/s$ $a = -g$

$v^2 = u^2 + 2gs$

$(0)^2 = u^2 - 19.8(10)$

$\sqrt{u^2} = \sqrt{198}$

$\underline{u = 14.071 m/s}$

let $u = V_0$ and resolve it into components

$V_{0x} = V_0 \cos\theta$ & $V_{0y} = V_0 \sin\theta$

$V_{0x} = 12.186 m/s$ $V_{0y} = 7.036 m/s$

the for the time in air

(a) $Y = 0m$

$\therefore Y = V_{0y} \sin\theta t - \frac{1}{2} g t^2$

$0 = 7.036(t) - 4.9t^2$

$t(7.036 - 4.9t) = 0$

$t = 0$ or $7.036 - 4.9t = 0$

$\underline{t = 1.436 sec}$

(b) $x = V\cos\theta\, t$

$x = 12.186\,(1.436)$

$x = 17.499\,m$

Q 20

Lets Resolve the velocity into components

X	Y
$V_{0x} = 45 \cos 20°$	$V_{0y} = 45 \sin 20°$
$V_{0x} = 42.286 m/s$	$V_{0y} = 15.391 m/s$

Lets analyse the x-axis

the displacement

$x = V_{0x} \cos\theta t$

$\therefore t = \frac{x}{V_{0x} \cos\theta}$

$\therefore t = \frac{80}{42.286}$

$\underline{t = 1.892 sec}$

Now lets analyse the Y-axis

$Y = V_{0y} \sin\theta t - \frac{1}{2} g t^2$

$Y = 15.391(1.892) - 4.9(1.892)^2$

$Y = 29.118 - 17.538$

$\therefore \underline{Y = 11.580 m}$

Now since the Y displacement is lower than the tree (12m), the ball will hit the tree

$\therefore 12m > 11.6m$

Q21

It the accelaration the graph
so at $t = 10s$, $a = 2m/s$ $u = 0m/s$

$v = u + at$

$v = 0 + 2(10)$

$v = 20m/s^2$

Now at $t = 20s$, we need to cover three stages first $0 \to 10s$ second $10 \to 15 sec$ and lastly $15 \to 20 sec$ we have solved for the first part.
so at $t = 10 \to 15 sec$ the time will be $5 sec$, $a = 0m/s^2$ $u = 20m/s$

$\therefore v = u + at$

$v = 20 + 0$

$v = 20m/s$

Now for $15 \to 20 sec$

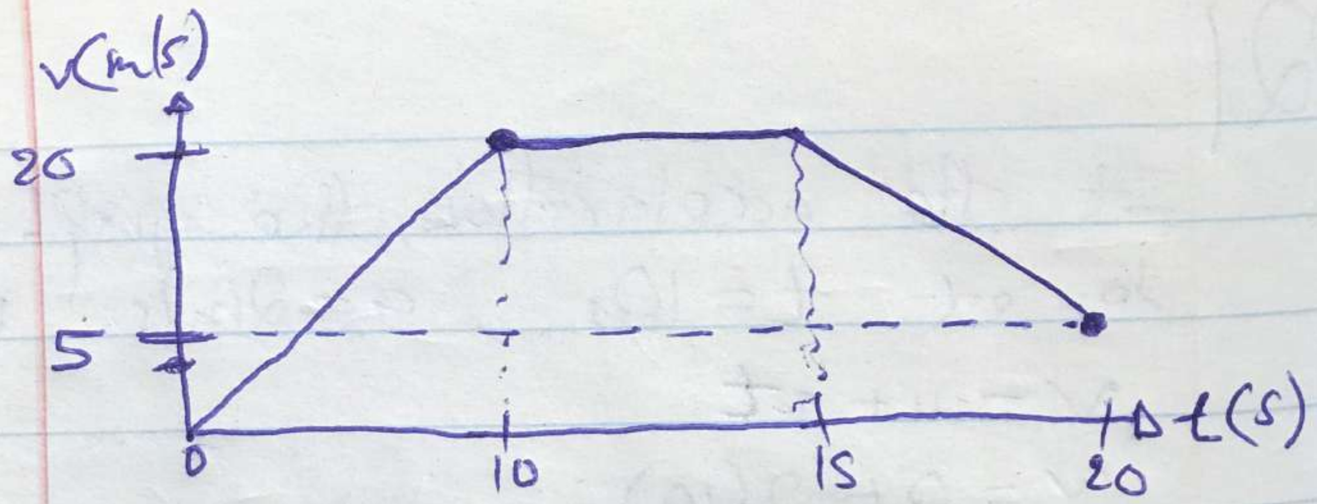
$a = -3m/s^2$ $t = 5 sec$ $u = 20m/s$

$v = u + at$

$v = 20 + (-3)(5)$

$v = 5m/s$

(b)



(c)

$x = \frac{1}{2}(t_1 V) + (t_2 V) + \frac{1}{2}\left[(V-u)(t_3)\right] + t_3(u$

$x = \frac{1}{2}(10 \times 20) + (5 \times 20) + \frac{1}{2}(15 \times 5) + 5(5)$

$x = 100 + 150 + 37.5 + 25$

$x = 262.5\,m$