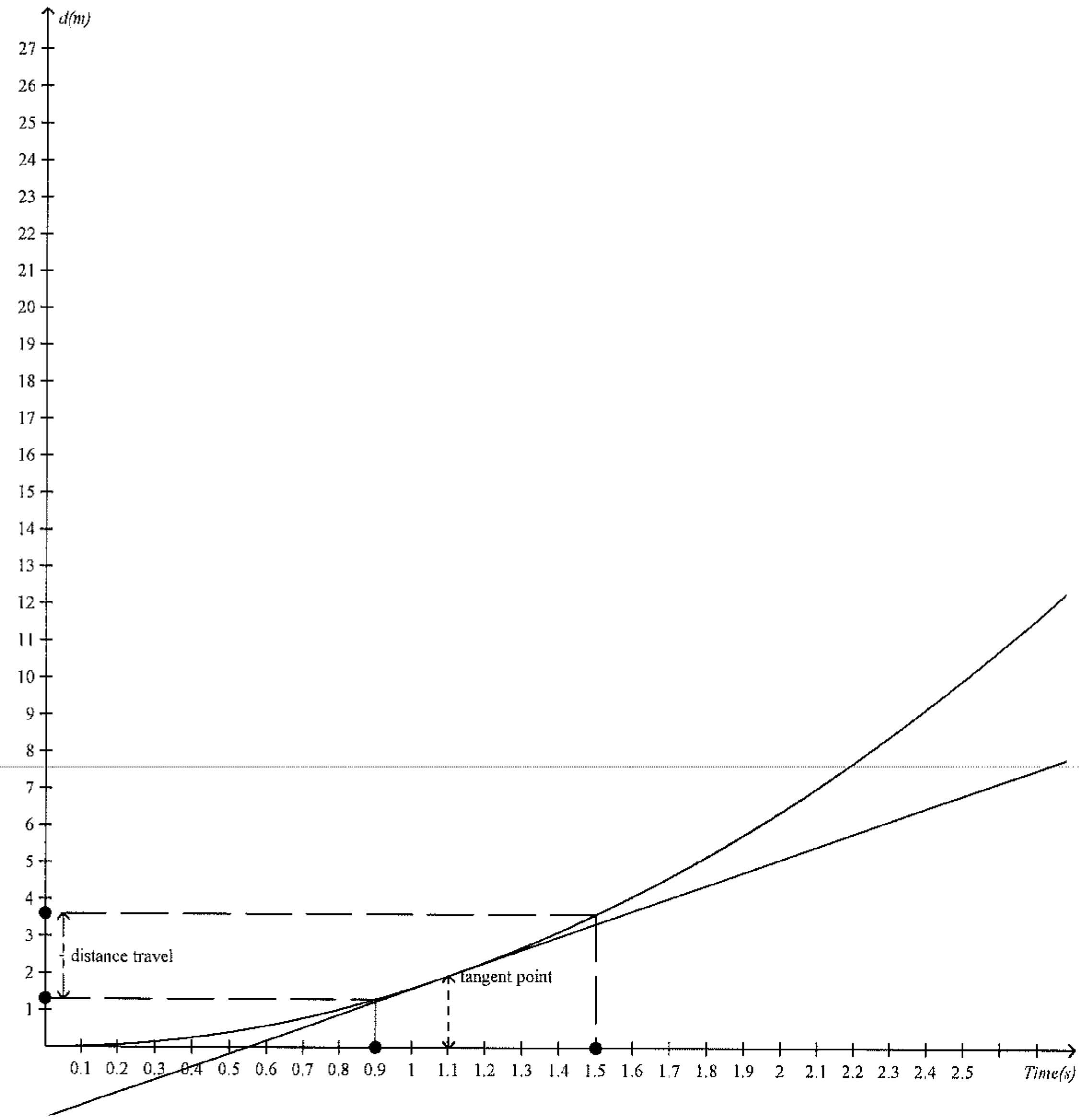
Ultimate Review
Answer Section

MULTIPLE CHOICE

1. D
2. B
3. B
4. C
5. D
6. C
7. D

SHORT ANSWER

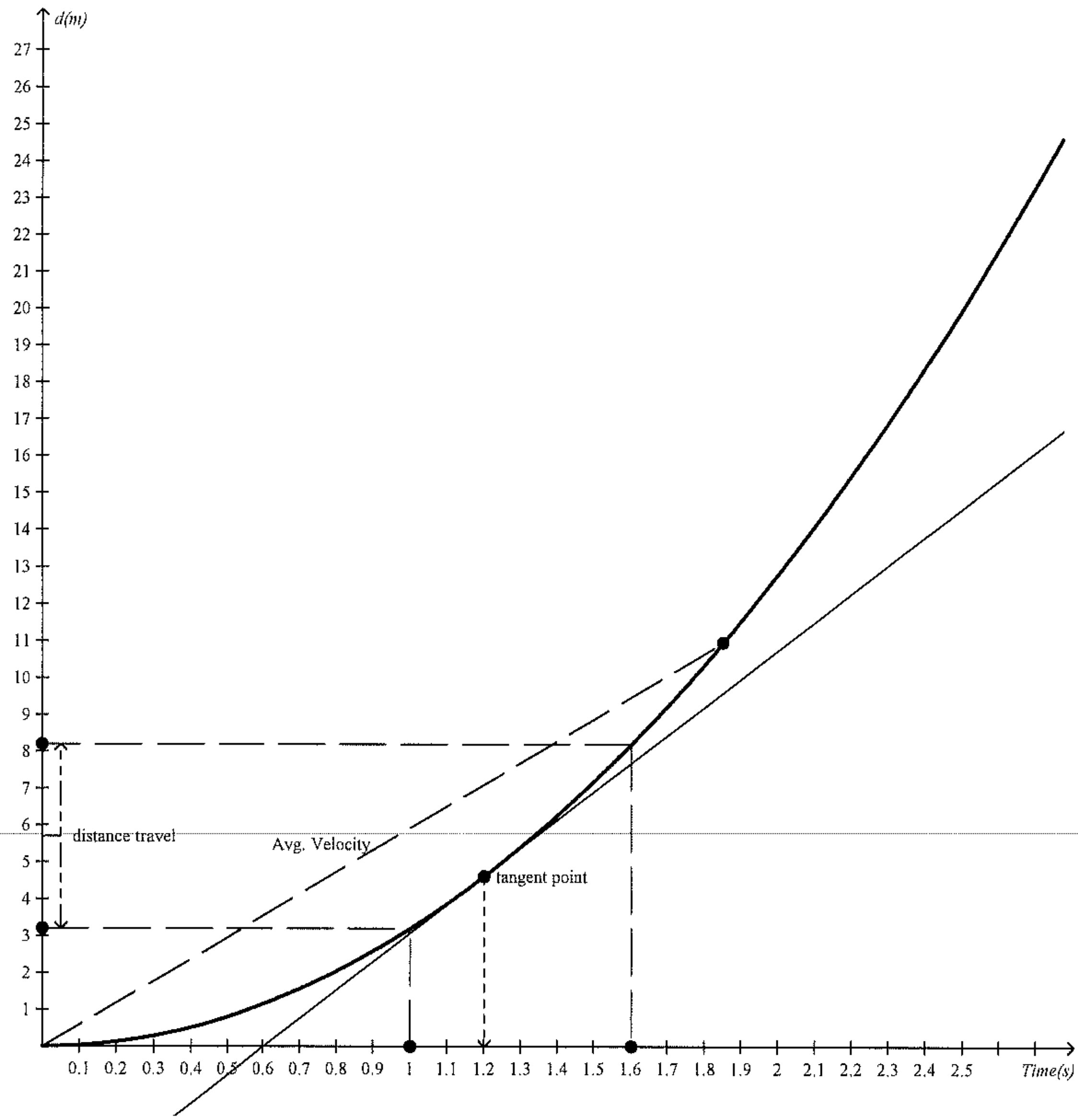


8.

a)Determine the instantaneous velocity at time 1.1s. **(1 mark)**
ANSWER: (1 mark)

The instantaneous velocity at time 1.1s is $m = \dfrac{y_2 - y_1}{x_2 - x_1} = \underline{\underline{3.52 m/s}}$

b) How far has the object travelled from 0.9s to 1.5s? **(1 mark)**
$d_1 = 1.3m$ and $d_2 = 3.6m$ The distance travelled is $d_2 - d_1 = 3.6m - 1.3m = \underline{\underline{2.3m}}$



9.

a)Determine the instantaneous velocity at time 1.2s. **(1 mark)**

ANSWER: (1 mark)

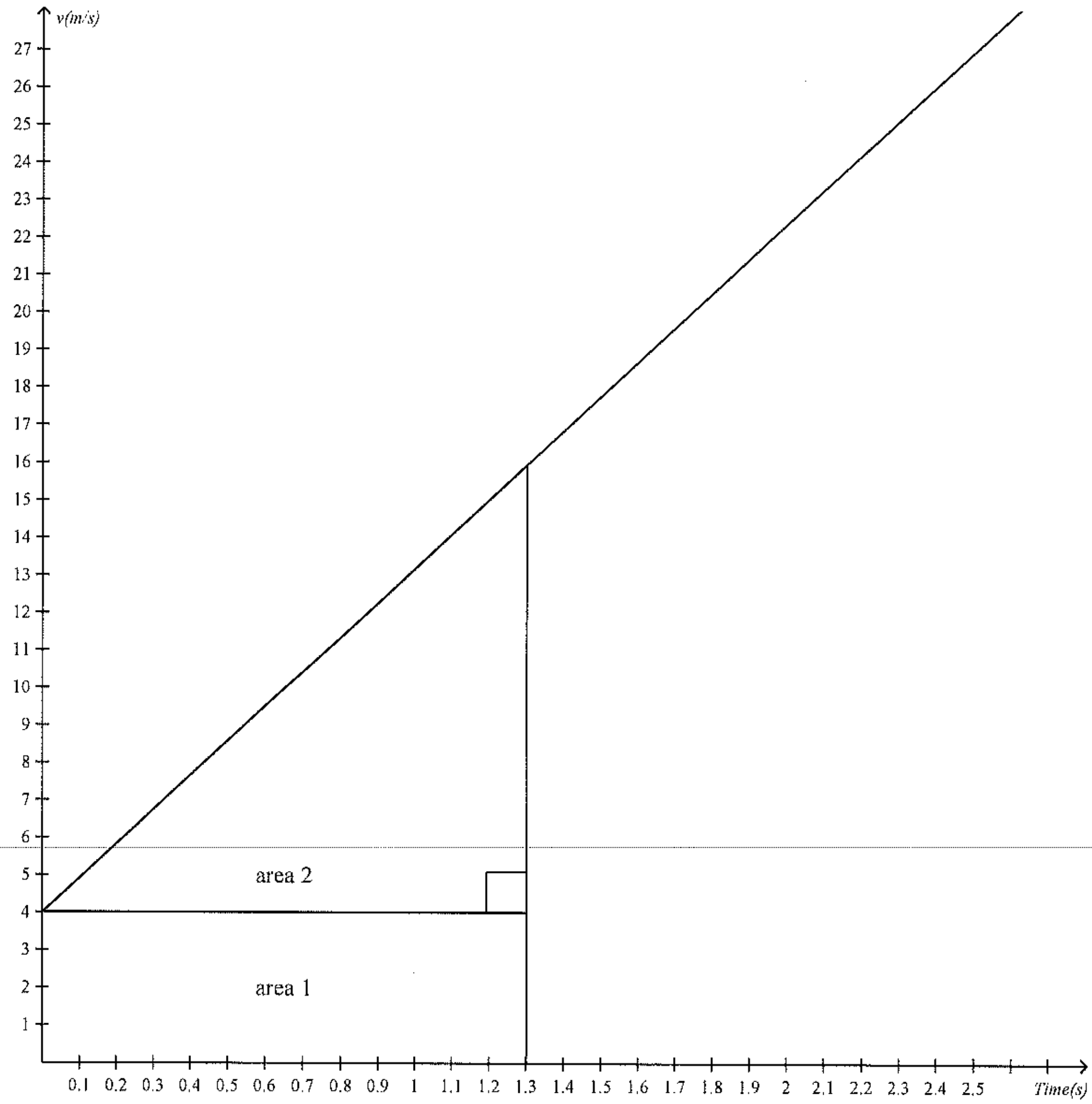
The instantaneous velocity at time 1.2s is $m = \dfrac{y_2 - y_1}{x_2 - x_1} = \underline{\underline{7.68 m/s}}$

b) How far has the object travelled from 1s to 1.6s? **(1 mark)**

$d_1 = 3.2m$ and $d_2 = 8.2m$ The distance travelled is $d_2 - d_1 = 8.2m - 3.2m = \underline{\underline{5m}}$

c) What is the average velocity from 0s to 1.6s? **(1 mark)**

$$v_{average} = \frac{d_{Total}}{t_{Total}} = \frac{8.2m}{1.85s} = \underline{\underline{5.92\frac{m}{s}}}$$



10.

From the graph...

a) Determine the distance travelled up to time 1.3s. **(1 mark)**

ANSWER: (1 mark)

Area1 is $time \cdot velocity = 1.3s \cdot 4m/s = 5.2m.$

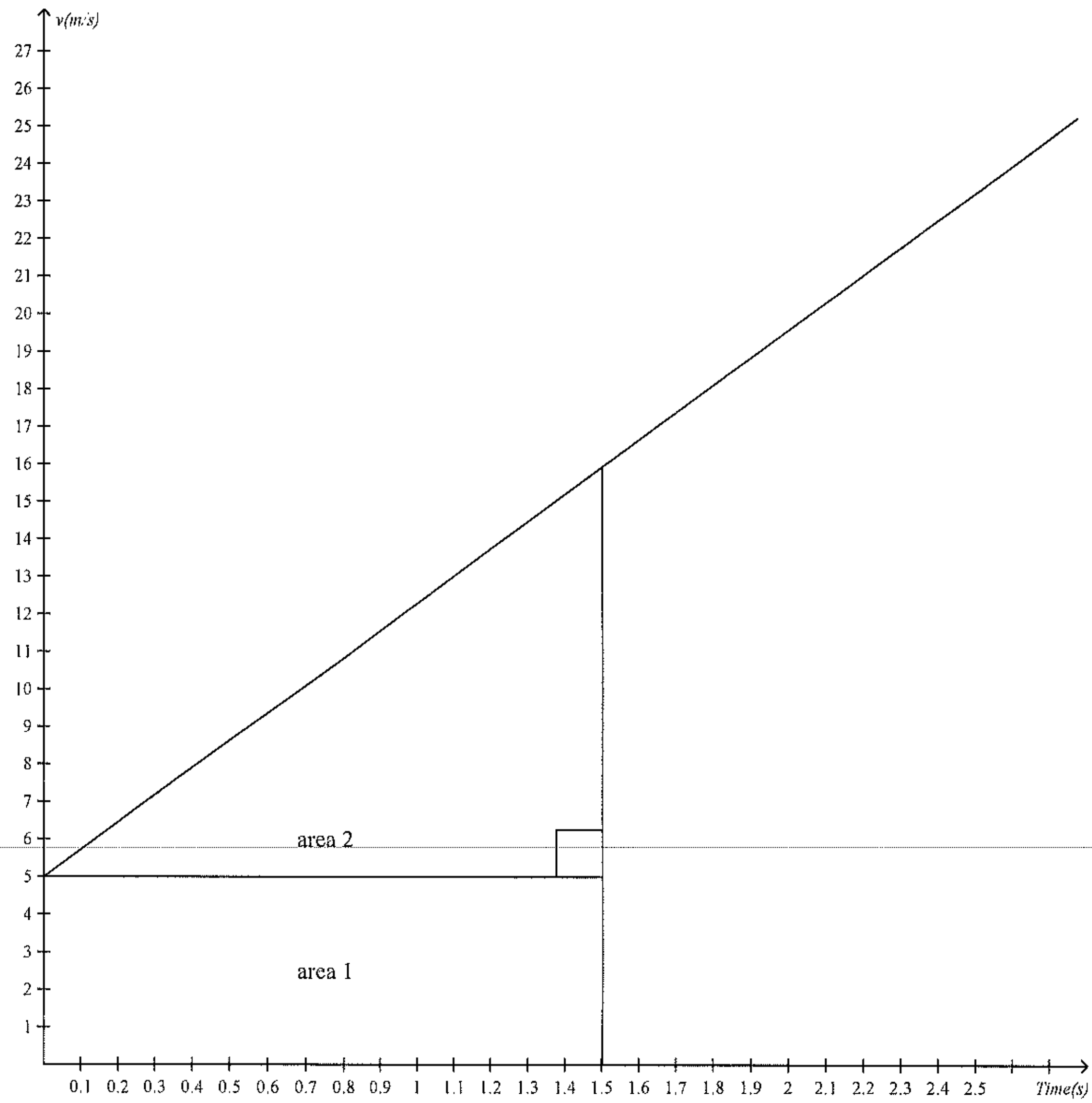
Area2 is $\frac{1}{2} \cdot time \cdot \left(v_f - v_i\right) = \frac{1}{2} \cdot 1.3s \cdot (15.96m/s - 4m/s) = 7.77m$

The total displacement is $5.2m + 7.77m = \underline{\underline{12.97m}}.$

b) Determine the acceleration of the object. **(1 mark)**

The acceleration of the object is found from the slope.

$$m = \frac{y_2 - y_1}{x_2 - x_1} = \underline{\underline{9.2m/s^2}}$$



11.

From the graph...

a) Determine the distance travelled up to time 1.5s. **(1 mark)**

ANSWER: (1 mark)

Area1 is $time \cdot velocity = 1.5s \cdot 5m/s = 7.5m.$

Area2 is $\frac{1}{2} \cdot time \cdot \left(v_f - v_i\right) = \frac{1}{2} \cdot 1.5s \cdot (15.95m/s - 5m/s) = 8.21m$

The total displacement is $7.5m + 8.21m = \underline{15.71m}.$

b) Determine the average velocity of the object up to time 1.5s. **(1 mark)**

$$v_{average} = \frac{d_T}{t_T} = \frac{15.71m}{1.5s} = \underline{\underline{10.48\,\frac{m}{s}}}$$

12. Tyler leaves the pool at a velocity of 5.5 km/h. After travelling for 34 minutes, Tyler's friend races after Tyler at 8.5 km/h.
a) How long does it take for the friend to catch up to Tyler? **(2 marks)**
ANSWER: (2 marks)
headstart distance = velocity of person x length of headstart

Convert head start time into hours = $\frac{34\,\text{min}}{60\,\text{min}/h}$ =0.57 *hours.*

headstart distance = $5.5km/h \times 34h = 3.1km$

Calculate the relative velocity = friend's velocity - $Tyler$' s velocity $= 8.5km/h - 5.5km/h = 3km/h$

The time it takes to catch up is t= $\frac{\text{head start distance (km)}}{\text{relative velocity (km/h)}} = \frac{3.1km}{3km/h}$ =$\underline{1.04hours = 62.3\,\text{min} = 3740s}$

b) How far from the pool are they when Tyler is caught? **(1 mark)**
ANSWER: (1 mark)
The distance from *the pool* is d = friend's velocity x time to catch up = $8.5km/h \times 1.04h = 8.83km$

OR d = $Tyler$' s velocity x (time to catch up + head start time) $= 5.5km/h \times (1.04h + 0.57h) = \underline{8.83km}$

13. Port Hardy is 371 km from Port Albernie. Train A leaves Port Hardy at a velocity of 74 km/h. at 6 am. and train B leaves Port Albernie at a velocity of 82 km/h also at 6 am.
a) At what time do they pass each other (to the nearest minute)? **(2 marks)**
ANSWER: (2 marks)
Calculate the relative velocity = Train A's velocity +Train B's velocity = $74km/h + 82km/h = 156km/h$

Determine how long it takes for the trains to pass each other.

time = $\frac{\text{distance the cities are apart}}{\text{relative velocity of the trains}} = \frac{371km}{156km/h}$ =$2.38hours$

Subtact $2h$ from $2.38h = 0.38hours$

Convert decimal hours into minutes = $0.38 \times \frac{60\,\text{min}}{h}$ =23 min

Add the time it takes to the time they left the station at 6am+2 + 23

They pass each other at $\underline{8{:}23am}$.

b) How far from Port Hardy are both trains when they pass each other? **(1 mark)**
ANSWER: (1 mark)
The distance from *Port Hardy* is = the time train A is travelling x the velocity of train A

$= 2.38h \times 74km/h = \underline{175.99km}$

14. A car starts from rest and travels 415 km in 8.5 hrs. What is the average velocity? **(2 marks)**
ANSWER: (2 marks)
d = 415 km, t = 8.5 h, v_{avg} =? km/h

$d = vt \qquad v = \frac{d}{t} = \frac{415\text{ km}}{8.5\text{ h}} = \underline{48.82\text{ km/h}}$

15. A car starts from rest and travels 240 km in 9.5 hrs. What is the average velocity? **(2 marks)**

ANSWER: (2 marks)

$d = 240$ km, $t = 9.5$ h, $v_{avg} = ?$ km/h

$$d = vt \qquad v = \frac{d}{t} = \frac{240 \text{ km}}{9.5 \text{ h}} = \underline{\underline{25.26 \text{ km/h}}}$$

16. You are going on a 386 km road trip, if you start from rest and travel 58 km/h for 2.3 hours, then stop for a lunch break for 54 minutes, how fast do you need to drive for if you are to have an average velocity of 61 km/h for the entire trip? **(3 marks)**

ANSWER: (3 marks)

First, you need to determine how long the whole trip is? $\text{time} = \frac{\text{total distance}}{\text{average velocity}} = \frac{386km}{61km/h} = 6.33hours$

Second, you need to determine how far you travelled in the first trip?

$\text{distance} = \text{velocity} \times \text{time} = 58km/h \times 2.3hours = 133.4km$

Third, you need to determine how much of the total time you have left after driving and stopping?

time left = total time - time driving - time stopped(convert to hours by /60)

$= 6.33 - 2.3 - 54/60\text{min} = 3.1hours$

Fourth, you need to determine how far you still have to go? $= 386km - 133.4km = 252.6km$

Fifth, to find the velocity at which you need to complete the trip with an average velocity of 61km/h, just divide the remaining distance by the remaining time.

$$= \frac{252.6km}{3.1hours} = \underline{\underline{80.76km/h}}$$

17. ~~You are going on a road trip. First you travel 60 km/h for 1.1 hours, then stop for a fill up for 56~~ minutes. Then you drive again for 45km at 57km/h. What is your average velocity for the whole trip? **(3 marks)**

ANSWER: (3 marks)

First, you need to determine how far you went for the first trip.

$\text{first distance} = \text{velocity} \cdot \text{time} = 60km/h \cdot 1.1s = 66km$

Second, you need to determine how long you waited in hours?

$$\frac{\text{breaktime minutes}}{60\text{ min/hour}} = \frac{56\text{ min}}{60\text{ min/hour}} = 0.93hours$$

Third, you need to determine how long you took for the third trip.

$$\text{time of third trip} = \frac{\text{distance}}{\text{velocity}} = \frac{45km}{57km/h} = 0.79h$$

Fourth, you need to determine how far you have driven and how long you have been on the road.

first distance + second distance = total distance

$66km + 45km = 111km$

time for first drive + time for break + time for second drive = total time

1.1h+0.93h+0.79h=2.82h

Finally, find the average velocity of the whole trip by dividing the total distance by the total time.

$$\text{Average Velocity} = \frac{\text{Total Distance km}}{\text{Total Time hours}} = \frac{111km}{2.82h} = \underline{\underline{39.32km/h}}$$

18. An astronaut breaks the Jupiter high jump record by jumping to a height of 16.6m with a vertical jump of 7.4 m/s. What is the gravitational acceleration on the surface of Jupiter? **(3 marks)**

ANSWER: (3 marks)

$v_i = 7.4m/s, \quad v_f = 0m/s, \quad d = 16.6m, \quad a = ?m/s^2$

$$\left(v_f\right)^2 = \left(v_i\right)^2 - 2ad \qquad a = \frac{\left(v_f\right)^2 - \left(v_i\right)^2}{2d} = \frac{0^2 m/s - (7.4m/s)^2}{(2)(16.6m)} = \underline{1.65m/s^2}$$

19. What would an astronaut's initial velocity be is they could jump to a height of 12.7m on the Mars. The gravitational acceleration on the surface of Mars is $7.4m/s^2$? **(3 marks)**

ANSWER: (3 marks)

$v_f = 0m/s$ (max height), $\quad d = 12.7m, \quad a = 7.4m/s^2, \quad v_i = ?m/s$

$$\left(v_f\right)^2 = \left(v_i\right)^2 - 2ad \qquad v_i = \sqrt{\left(v_f\right)^2 - 2ad} = \sqrt{0 - 2(-7.4m/s^2)(12.7m)} = \underline{13.71m/s}$$

20. A car traveling at 93.8 m/s applies the brakes and slows down at a constant rate to 24.3 m/s in 563.8 meters.
How long does it take the car to slow down? **(3 marks)**

ANSWER: (3 marks)

$v_i = 93.8m/s, \quad v_f = 24.3m/s, \quad d = 563.8m, \quad t = ?s$

$$d = \left(\frac{v_f + v_i}{2}\right)t \qquad t = \frac{2 \cdot d}{\left(v_f + v_i\right)} = \frac{2 \cdot 563.8m}{(24.3m/s + 93.8m/s)} = \underline{9.55s}$$

21. A truck is travelling at 10m/s then it accelerates at a rate of $8m/s^2$ for 15s.
How far has it travelled in the time it was accelerating? **(3 marks)**

ANSWER: (3 marks)

$v_i = 10m/s, \quad a = 8m/s^2, \quad t = 15s, \quad d = ?m$

$$d = v_i t + \tfrac{1}{2}at^2 = 10m/s \cdot 15s + \tfrac{1}{2} \cdot 8m/s^2 \cdot (15s)^2 = \underline{1050m}$$

22. How high do you have to be to drop a rock so that it hits the ground in 19.2 seconds? **(3 marks)**
ANSWER: (3 marks)

$v_i = 0m/s, \quad a = 9.8m/s^2, \quad t = 19.2s, \quad d = ?m$

$$d = v_i t + \tfrac{1}{2}at^2 = 0m/s \cdot 19.2s + \tfrac{1}{2} \cdot 9.8m/s^2 \cdot (19.2s)^2 = \underline{1806.34m}$$

23. A ball is dropped off a building and 2.3 seconds later a second ball is thrown upwards at 5.4 m/s. How far apart are the balls when the second ball is moving at -29.7 m/s? **(3 marks)**

ANSWER: (3 marks)
First, find how long it takes for the second ball to reach it's final velocity of -29.7 m/s.
$v_{i_2} = 5.4m/s, \quad v_{f_2} = -29.7m/s, \quad a = -9.8m/s^2, \quad t = ?s$ Second, find how far the second ball has

$$v_{f_2} = v_{i_2} + at \qquad t = \frac{v_{f_2} - v_{i_2}}{a} = \frac{-29.7m/s - 5.4m/s}{-9.8m/s^2} = 3.58s$$

fallen in that time.
$v_i = 5.4m/s, \quad a = -9.8m/s^2, \quad t = 3.58s, \quad d = ?m$

$$d = v_i t + \tfrac{1}{2}at^2 = 5.4m/s \times 3.58s + \tfrac{1}{2}(-9.8m/s^2)(3.58)^2 = -43.52m$$

Third, find how far the first ball has fallen in the total time (headstart time + time of second object).
$v_{i_1} = 0m/s, \quad a = -9.8m/s^2, \quad t = 2.3s + 3.58s = 5.88s, \quad d = ?m$

$$d = v_{i_1} t + \tfrac{1}{2}at^2 = \tfrac{1}{2}(-9.8m/s^2)(5.88s)^2 = -169.51m$$

Finally, find the distance the two balls are apart.
$d_1 = -169.51m, \quad d_2 = -43.52m$

distance apart $= |d_1 - d_2| = |-169.51m - -43.52m| = \underline{125.99m}$

24. A math book is dropped off a building and 5.1 seconds later a second math book is thrown upwards at 2.2 m/s. How far apart are the math books when the second math book has fallen to -37 m? **(3 marks)**

ANSWER: (3 marks)
First, find fast the second math book is moving when it reached -37m.

$v_{i_2} = 2.2m/s$

$d = -37m$

$a = -9.8m/s^2$

$v_{f_2} = m/s$

$\left(v_{f_2}\right)^2 = \left(v_{i_2}\right)^2 + 2ad$

$v_{f_2} = \sqrt{(2.2m/s)^2 + 2\left(-9.8m/s^2\right)(-37m)} = -27m/s$

We need to add the negative sign to the final velocity since the object is below the start point.
Second, find how long it has taken the second math book to fall that distance.

$v_{i_2} = 2.2m/s$

$v_{f_2} = -27m/s$

$a = -9.8m/s^2$

$t = 2.98s$

$v_{f_2} = v_{i_2} + at$

$t = \dfrac{v_{f_2} - v_{i_2}}{a} = \dfrac{-27m/s - 2.2m/s}{-9.8m/s^2} = 2.98s$

Third, find how far the first math book has fallen in the total time (headstart time + time of second object).

$v_{i_1} = 0m/s$

$t = 5.1s + 2.98s = 8.08s$

$a = -9.8m/s^2$

$d = ?m$

$d = v_i t + \frac{1}{2}at^2 = (0m/s)(8.08s) + \frac{1}{2}(-9.8m/s^2)(8.08s)^2 = -320.03m$

Finally, find the distance the two math books are apart.

$d_1 = -320.03m$

$d_2 = -37m$

distance apart $= \left|d_1 - d_2\right| = \left|-320.03m - 37m\right| = \underline{\underline{283.03m}}$

25. A projectile is fired straight up with an initial velocity of 17.8 m/s. If air resistance is negligible, how much time elapses before the projectile reaches its maximum height? **(3 marks)**

ANSWER: (3 marks)
$v_f = 0\,m/s\,(\max height), \quad v_i = 17.8\,m/s, \quad a = -9.8\,m/s^2, \quad t = ?\,s$

$$v_f = v_i + at \qquad t = \frac{v_f - v_i}{a} = \frac{0m/s - 17.8m/s}{-9.8m/s^2} = \underline{1.82s}$$

26. A boy is standing on the edge of a 42 m cliff and he throws a ball straight up with an initial velocity of 14.7 m/s. If air resistance is negligible, how fast is the ball moving when it is 8.3 m below the edge of the cliff? **(3 marks)**
ANSWER: (3 marks)
$v_i = 14.7\,m/s, \quad a = -9.8\,m/s^2, \quad d = -8.3m, \quad v_f = ?\,m/s$

$$\left(v_f\right)^2 = \left(v_i\right)^2 + 2ad \qquad v_f = \sqrt{\left(v_i\right)^2 + 2ad} = \sqrt{(14.7m/s)^2 + 2\cdot\left(-9.8\tfrac{m}{s^2}\right)\cdot(-8.3m)} = \underline{19.46m/s}$$

27. A car traveling at 24 m/s speeds up going down a hill, and is moving at a rate of 66 m/s 46.5 seconds later.
a) What is the rate of acceleration? **(2 marks)**
ANSWER: (2 marks)
$v_i = 24m/s, \quad v_f = 66m/s, \quad t = 46.5s, \quad a = ?\,m/s^2$

$$v_f = v_i + at \qquad a = \frac{(v_f - v_i)}{t} = \frac{(66m/s - 24m/s)}{46.5s} = \underline{0.9m/s^2}$$

b) How far has the car in traveled in the 46.5 seconds? **(2 marks)**
$v_i = 24m/s, \quad v_f = 66m/s, \quad t = 46.5s, \quad a = 0.9m/s^2$

Since you know all the variables, you can use any of the formulas that have '*d*' in them.

$$(v_f)^2 = (v_i)^2 + 2ad \quad \text{OR} \quad d = \frac{\left(v_f + v_i\right)}{2}t \quad \text{OR} \quad d = v_i t + \frac{1}{2}at^2$$

$$d = \frac{(v_f)^2 - (v_i)^2}{2a} = \frac{(66m/s)^2 - (24m/s)^2}{2\cdot 0.9m/s^2} = \underline{2092.5m}$$

$$d = \frac{\left(v_f + v_i\right)}{2}t = \frac{(66m/s + 24m/s)}{2}46.5s = \underline{2092.5m}$$

$$d = v_i t + \frac{1}{2}at^2 = 24m/s\cdot 46.5s + \frac{1}{2}\cdot 0.9m/s^2\cdot(46.5s)^2 = \underline{2092.5m}$$

28. An archer standing on a 29 m high wall fires an arrow horizontally at a rate of 20 m/s. How close to the wall can the enemy get before getting hit in the toes by arrows? **(3 marks)**
ANSWER: (3 marks)
First we need to solve for t using $d_y = \frac{1}{2}at^2$

$d_y = -29m, \quad a = -9.8m/s^2, \quad t = ?s$

$$d_y = \frac{1}{2}at^2 \qquad t = \sqrt{\frac{2 \cdot d_y}{a}} = \sqrt{\left(\frac{2 \cdot (-29m)}{-9.8m/s^2}\right)} = 2.43s$$

Now we can determine the d_x by using $d_x = v_x \cdot t$

$t = 2.43s, \quad v_x = 20m/s, \quad d_x = ?m$

$d_x = v_x \cdot t = 20m/s \cdot 2.43s = \underline{\underline{48.66m}}$

29. A rock is thrown horizontally off a cliff of height 53 m at a velocity of 6 m/s. How far from the base of the cliff does it land? **(3 marks)**

ANSWER: (3 marks)
First we need to solve for t using $d_y = \frac{1}{2}at^2$

$d_y = -53m, \quad a = -9.8m/s^2, \quad t = ?s$

$$d_y = \frac{1}{2}at^2 \qquad t = \sqrt{\frac{2 \cdot d_y}{a}} = \sqrt{\left(\frac{2 \cdot (-53m)}{-9.8m/s^2}\right)} = 3.29s$$

Now we can determine the d_x by using $d_x = v_x \cdot t$

$t = 3.29s, \quad v_x = 6m/s, \quad d_x = ?m$

$d_x = v_x \cdot t = 6m/s \cdot 3.29s = \underline{\underline{19.73m}}$

30. A rock is thrown horizontally off a cliff at a velocity of 10 m/s. If it lands 43 m from the base of the cliff, how high is the cliff? **(3 marks)**

ANSWER: (3 marks)
First we need to solve for t using $d_x = v_x \cdot t$

$v_x = 10m/s, \quad d_x = 43m, \quad t = ?s$

$$d_x = v_x \cdot t \qquad t = \frac{d_x}{v_x} = \frac{43m}{10m/s} = 4.3s$$

Now we can determine the d_y by using the formula $d_y = \frac{1}{2}at^2$

$a = -9.8m/s^2, \quad t = 4.3s, \quad d_y = -?m$

$d_y = \frac{1}{2}at^2 = \frac{1}{2}(-9.8m/s^2)(4.3s)^2 = -\underline{\underline{90.6m}}$

31. A rock is thrown horizontally off a cliff of height 48 m and lands 25m from the base of the cliff. How fast was it moving when it was thrown off the cliff? **(3 marks)**

ANSWER: (3 marks)
First we need to solve for t using $d_y = \frac{1}{2}at^2$

$d_y = -48m, \quad a = -9.8m/s^2, \quad t = ?\,s$

$$d_y = \frac{1}{2}at^2 \qquad t = \sqrt{\frac{2 \cdot d_y}{a}} = \sqrt{\left(\frac{2 \cdot (-48m)}{-9.8m/s^2}\right)} = 3.13s$$

Now we can determine the v_x by using $d_x = v_x \cdot t$

$t = 3.13s, \quad d_x = 25m, \quad v_x = ?\,m/s$

$$d_x = v_x \cdot t \qquad v_x = \frac{d_x}{t} = \frac{25m}{3.13s} = \underline{\underline{7.99m/s}}$$

32. A prisoner wants to jump over the 3.3 m fence that is 15 m away from the edge of the 20 m high prison building. What is the minimum velocity the prisoner needs to run to just clear the fence? **(3 marks)**
ANSWER: (3 marks)
First we need to solve for t using $d_y = \frac{1}{2}at^2$

$d_y = -(20 - 3.3)m, \quad a = -9.8m/s^2, \quad t = ?\,s$

$$d_y = \frac{1}{2}at^2 \qquad t = \sqrt{\frac{2 \cdot d_y}{a}} = \sqrt{\left(\frac{2 \cdot (-16.7m)}{-9.8m/s^2}\right)} = 1.85s$$

Now we can determine the v_x by using $d_x = v_x \cdot t$

$t = 1.85s, \quad d_x = 15m, \quad v_x = ?\,m/s$

$$d_x = v_x \cdot t \qquad v_x = \frac{d_x}{t} = \frac{15m}{1.85s} = \underline{\underline{8.13m/s}}$$

b) What is the prisoner's vertical velocity when he hits the ground? **(2 marks)**
$d_y = -20m, \quad a = -9.8m/s^2, \quad v_i = 0m/s, \quad v_f = ?\,m/s$

$$\left(v_f\right)^2 = \left(v_i\right)^2 + 2ad_y = (0m/s)^2 + 2 \cdot \left(-9.8m/s^2\right) \cdot (-20m) = \sqrt{2 \cdot \left(-9.8m/s^2\right) \cdot (-20m)} = \underline{\underline{19.8m/s}}$$

33. A prisoner who can run at 6.6m/s, wants to jump over the 4.5 m fence that is 13 m away from the edge of a prison building.

a) What is the minimum height the building needs to be so the prisoner will just clear the fence? **(3 marks)**

ANSWER: (3 marks)

First we need to solve for t using $= t$

$d_x = 13m, \quad v_x = 6.6m/s, \quad t = ?s$

$$t = \frac{d_x}{v_x} = 1.97s$$

Now we can determine the d_y by using $d_y = \frac{1}{2}at^2$

$a = -9.8m/s^2, \quad t = 1.97s$

$$d_y = \frac{1}{2}at^2 = \frac{1}{2}\left(-9.8m/s^2\right)(1.97s)^2 = -19.01m$$

Now add the height to the fence height to get the height of the prison building.

prison building $= (19.01m + 4.5m) = \underline{23.51m}$

b) What is the prisoner's vertical velocity when he hits the ground? **(2 marks)**

$d_y = -23.51m, \quad a = -9.8m/s^2, \quad v_i = 0m/s, \quad v_f = ?m/s$

$$\left(v_f\right)^2 = \left(v_i\right)^2 + 2ad_y = (0m/s)^2 + 2\cdot\left(-9.8m/s^2\right)\cdot(-23.51m) = \sqrt{2\cdot\left(-9.8m/s^2\right)\cdot(-23.51m)} = \underline{\underline{21.47m/s}}$$

34. Mr. Roome is dropping water-balloons on students as they pass under an over-head-walkway. If he is 20 m above the student's heads and they are walking at a rate of 6.3 m/s, at what horizontal distance before the students pass underneath, should he drop the balloons to get a head-shot? **(3 marks)**

ANSWER: (3 marks)

First we need to solve for t using $d_y = \frac{1}{2}at^2$

$d_y = -20m, \quad a = -9.8m/s^2, \quad t = ?s$

$$d_y = \frac{1}{2}at^2 \qquad t = \sqrt{\frac{2\cdot d_y}{a}} = \sqrt{\left(\frac{2\cdot(-20m)}{-9.8m/s^2}\right)} = 2.02s$$

Now we can determine the d_x by using $d_x = v_x \cdot t$

$t = 2.02s, \quad v_x = 6.3m/s, \quad d_x = ?m$

$d_x = v_x \cdot t = 6.3m/s \cdot 2.02s = \underline{12.73m}$

35. An airplane is flying along at 400 km/h and at an altitude of 2875 m. An enemy tank is moving towards the plane at 30 km/h. How far from the tank (directly below the plane) should the plane drop the bomb so it hits the tank? **(3 marks)**

ANSWER: (3 marks)

First, determine the time it takes for the bomb to hit the ground.

$d_y = -2875m, \quad a = -9.8m/s^2, \quad t = ?s$

$$d_y = \frac{1}{2}at^2 \qquad t = \sqrt{\frac{2d_y}{a}} = \sqrt{\frac{2 \cdot -2875m}{-9.8m/s^2}} = \underline{\underline{24.22s}}$$

Second, determine how far the bomb travels in 24.22s.

$v_{plane} = 400km/h = 111.11m/s, \quad t = 24.22s, \quad d_{bomb} = ?m$

$d_{bomb} = v_{bomb} \cdot time = 111.11m/s \cdot 24.22s = 2,691.4m$

Third, determine how far the tank travels in 24.22s.

$v_{\tan k} = 30km/h = 8.33m/s, \quad t = 24.22s, \quad d_{\tan k} = ?m$

$d_{\tan k} = v_{\tan k} \cdot time = 8.33m/s \cdot 24.22s = 201.86m$

Finally, determine the distance away from tank to drop the bomb. Because the tank is moving towards the plane, we have to drop the bomb earlier so the distance is farther.

$d_{drop} = d_{bomb} + d_{\tan k} = 2,691.4m + 201.86m = \underline{\underline{2,893.26m}}$

36. An airplane is flying along at 370 km/h and at an altitude of 2350 m. An enemy tank is moving in the same direction as the plane at 55 km/h. How far from the tank (directly below the plane) should the plane drop the bomb so it hits the tank? **(3 marks)**

ANSWER: (3 marks)

First, determine the time it takes for the bomb to hit the ground.

$d_y = -2350m, \quad a = -9.8m/s^2, \quad t = ?s$

$$d_y = \frac{1}{2}at^2 \qquad t = \sqrt{\frac{2d_y}{a}} = \sqrt{\frac{2 \cdot -2350m}{-9.8m/s^2}} = \underline{21.9s}$$

Second, determine how far the bomb travels in 21.9s.

$v_{plane} = 370km/h = 102.78m/s, \quad t = 21.9s, \quad d_{bomb} = ?m$

$d_{bomb} = v_{bomb} \cdot time = 102.78m/s \cdot 21.9s = 2,250.79m$

Third, determine how far the tank travels in 21.9s.

$v_{\tan k} = 55km/h = 15.28m/s, \quad t = 21.9s, \quad d_{\tan k} = ?m$

$d_{\tan k} = v_{\tan k} \cdot time = 15.28m/s \cdot 21.9s = 334.58m$

Finally, determine the distance away from tank to drop the bomb. Because the tank is moving in the same direction as the plane, we have to drop the bomb later so the distance is closer.

$d_{drop} = d_{bomb} - d_{\tan k} = 2,250.79m - 334.58m = \underline{1,916.21m}$

37. What is the gravitational acceleration of a planet if an astronaut runs at a rate of 5.1 m/s off a 98 m hill and lands 16 m from the base of the hill? **(3 marks)**

ANSWER: (3 marks)

First, find how long it takes to travel 16m at a rate of 5.1m/s.

$v_x = 5.1m/s, \quad d_x = 16m$

$$d_x = v_x t \qquad t = \frac{d_x}{v_x} = \frac{16m}{5.1m/s} = 3.14s$$

Now, determine the acceleration due to gravity.

$d_y = 98m, \quad t = 3.14s, \quad a = ?m/s^2$

$$d_y = \frac{1}{2}at^2 \qquad a = \frac{2 \cdot d_y}{t^2} = \frac{2 \cdot 98m}{(3.14s)^2} = \underline{19.91m/s^2}$$

38. How high is a building if a runner running at 9.1 m/s can land 11 m from the base of the building (ignore broken bones or death upon landing)? **(3 marks)**
ANSWER: (3 marks)
First, find how long it takes to travel 11m at a rate of 9.1m/s.

$v_x = 9.1m/s, \quad d_x = 11m$

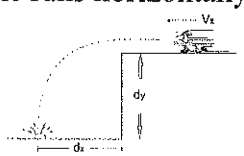
$d_x = v_x t \qquad t = \frac{d_x}{v_x} = \frac{11m}{9.1m/s} = 1.21s$

Now, determine the height of the building.

$t = 1.21s, \quad a = -9.8m/s^2, \quad d_y = ?\, m$

$d_y = \frac{1}{2}at^2 = \frac{1}{2}(-9.8m/s^2)(1.21s)^2 = \underline{7.16m}$ (ignore the negative as we are looking for height)

39. Mike runs horizontally off a cliff at 8.4 m/s and lands in the water 10.3 m from the base of the cliff.

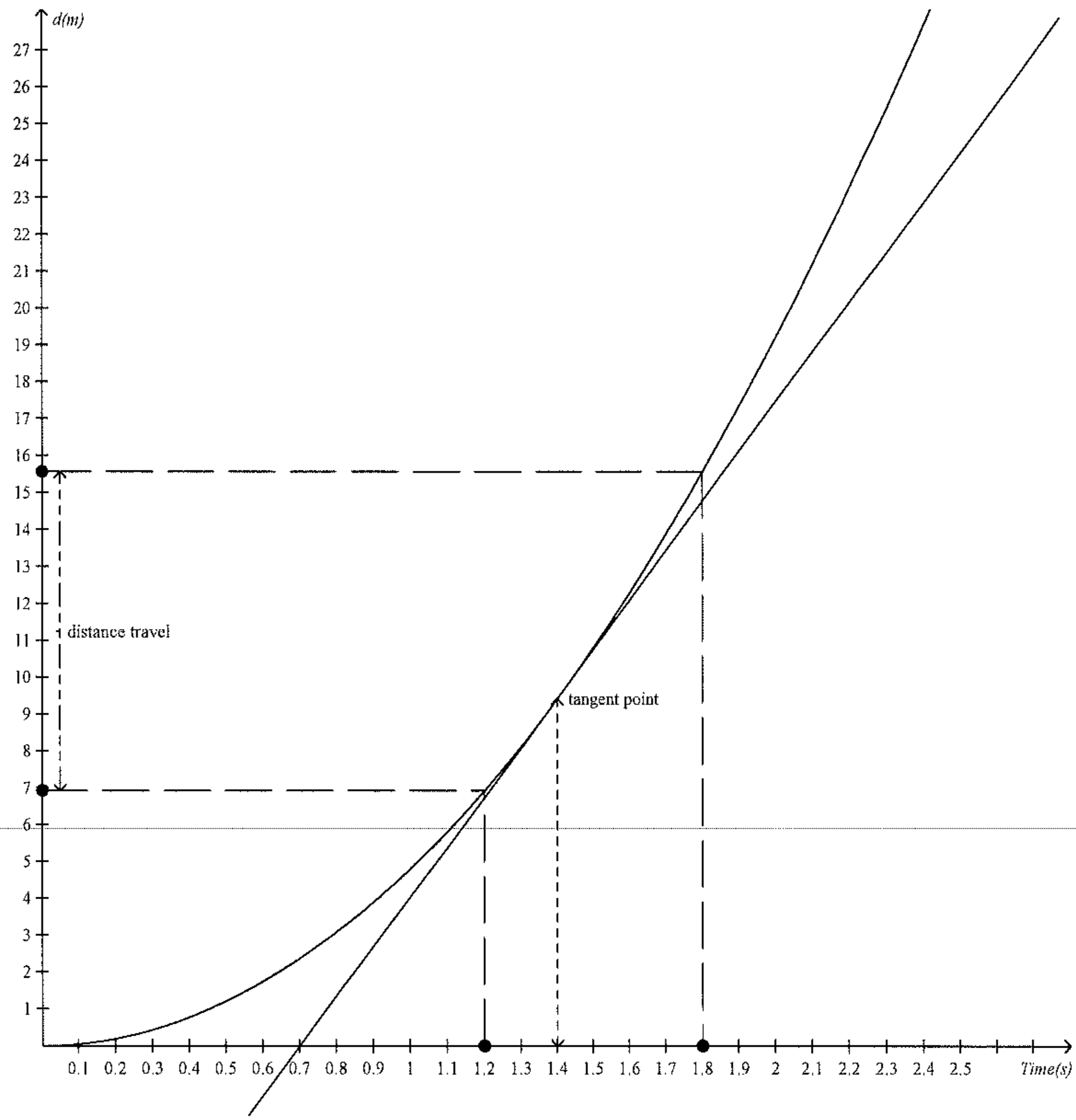


a) How long does it take Mike to hit the water? **(1 mark)**
ANSWER: (1 mark)
$d_x = 10.3m, \quad v_x = 8.4m/s, \quad t = ?\, s$

$d_x = v_x t \qquad t = \frac{d_x}{v_x} = \frac{10.3m}{8.4m/s} = \underline{\underline{1.23s}}$

b) How high is the cliff? **(2 marks)**
$d_y = ?\, m, \quad v_{yi} = 0m/s, \quad t = 1.23s, \quad a = -9.8m/s^2$

$d_y = v_{yi}t + \frac{1}{2}at^2 \qquad d_y = (0m/s)(1.23s) + \frac{1}{2}(-9.8m/s^2)(1.23s)^2 = \underline{\underline{7.37m}}$

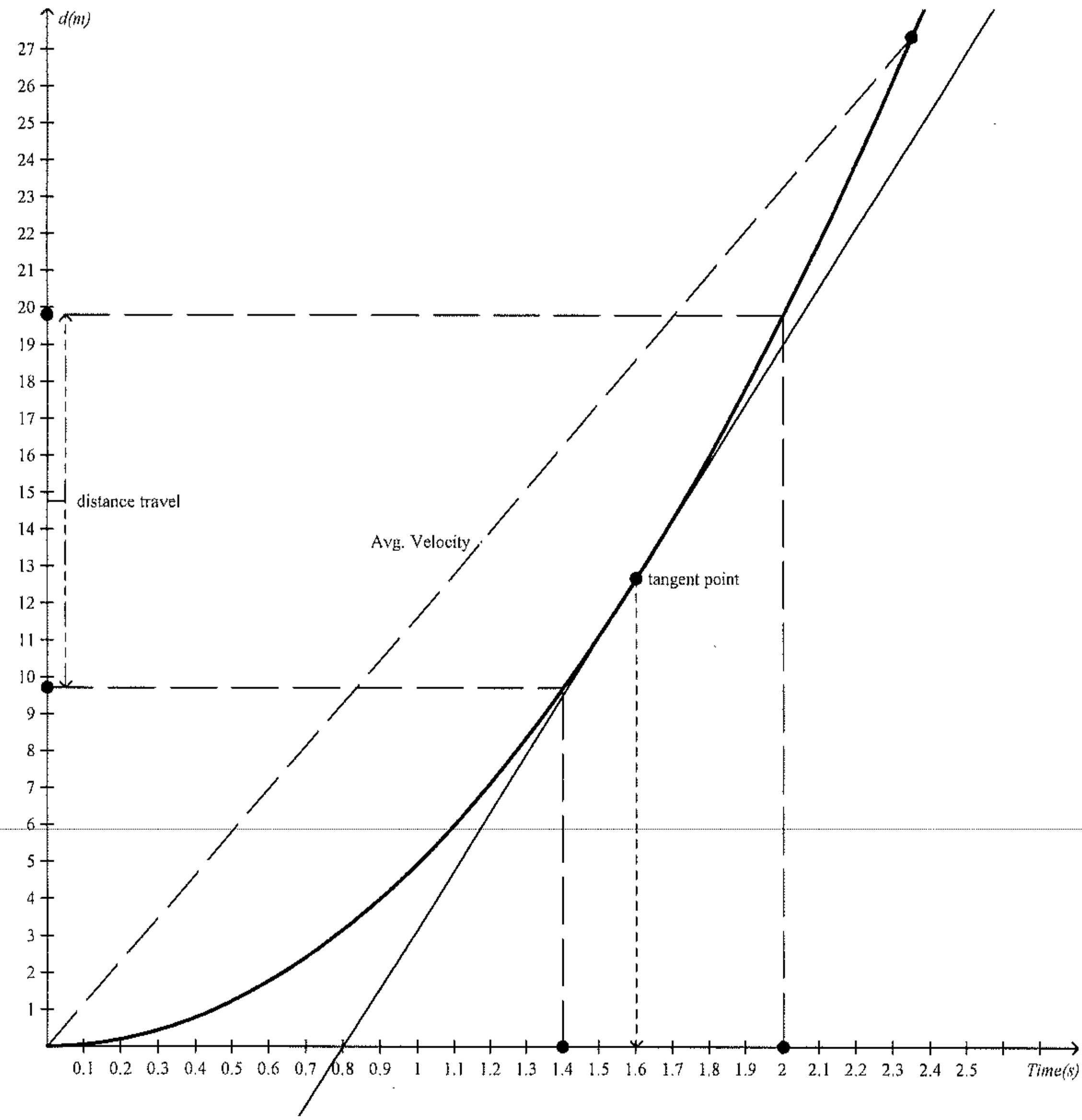


40.

a)Determine the instantaneous velocity at time 1.4s. **(1 mark)**
ANSWER: (1 mark)

The instantaneous velocity at time 1.4s is $m = \frac{y_2 - y_1}{x_2 - x_1} = \underline{\underline{13.44m/s}}$

b) How far has the object travelled from 1.2s to 1.8s? **(1 mark)**
$d_1 = 6.9m$ and $d_2 = 15.6m$ The distance travelled is $d_2 - d_1 = 15.6m - 6.9m = \underline{\underline{8.6m}}$



41.

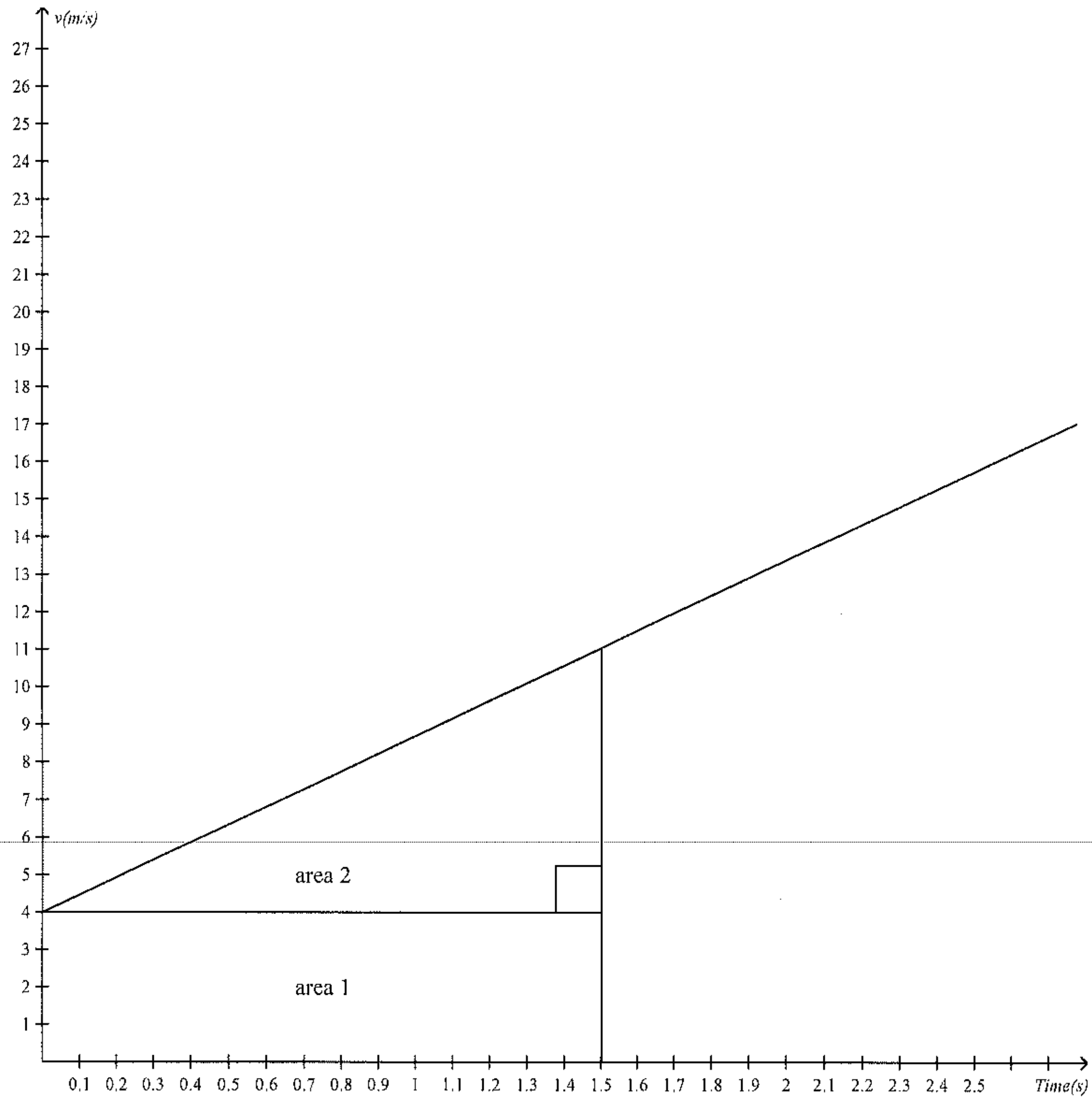
a)Determine the instantaneous velocity at time 1.6s. **(1 mark)**
ANSWER: (1 mark)

The instantaneous velocity at time 1.6s is $m = \dfrac{y_2 - y_1}{x_2 - x_1} = \underline{\underline{15.84 m/s}}$

b) How far has the object travelled from 1.4s to 2s? **(1 mark)**
$d_1 = 9.7m$ and $d_2 = 19.8m$ The distance travelled is $d_2 - d_1 = 19.8m - 9.7m = \underline{\underline{10.1m}}$

c) What is the average velocity from 0s to 2s? **(1 mark)**

$$v_{average} = \frac{d_{Total}}{t_{Total}} = \frac{19.8m}{2.35s} = \underline{\underline{11.63\,\frac{m}{s}}}$$



42.

From the graph...

a) Determine the distance travelled up to time 1.5s. **(1 mark)**

ANSWER: (1 mark)

Area1 is $time \cdot velocity = 1.5s \cdot 4m/s = 6m.$

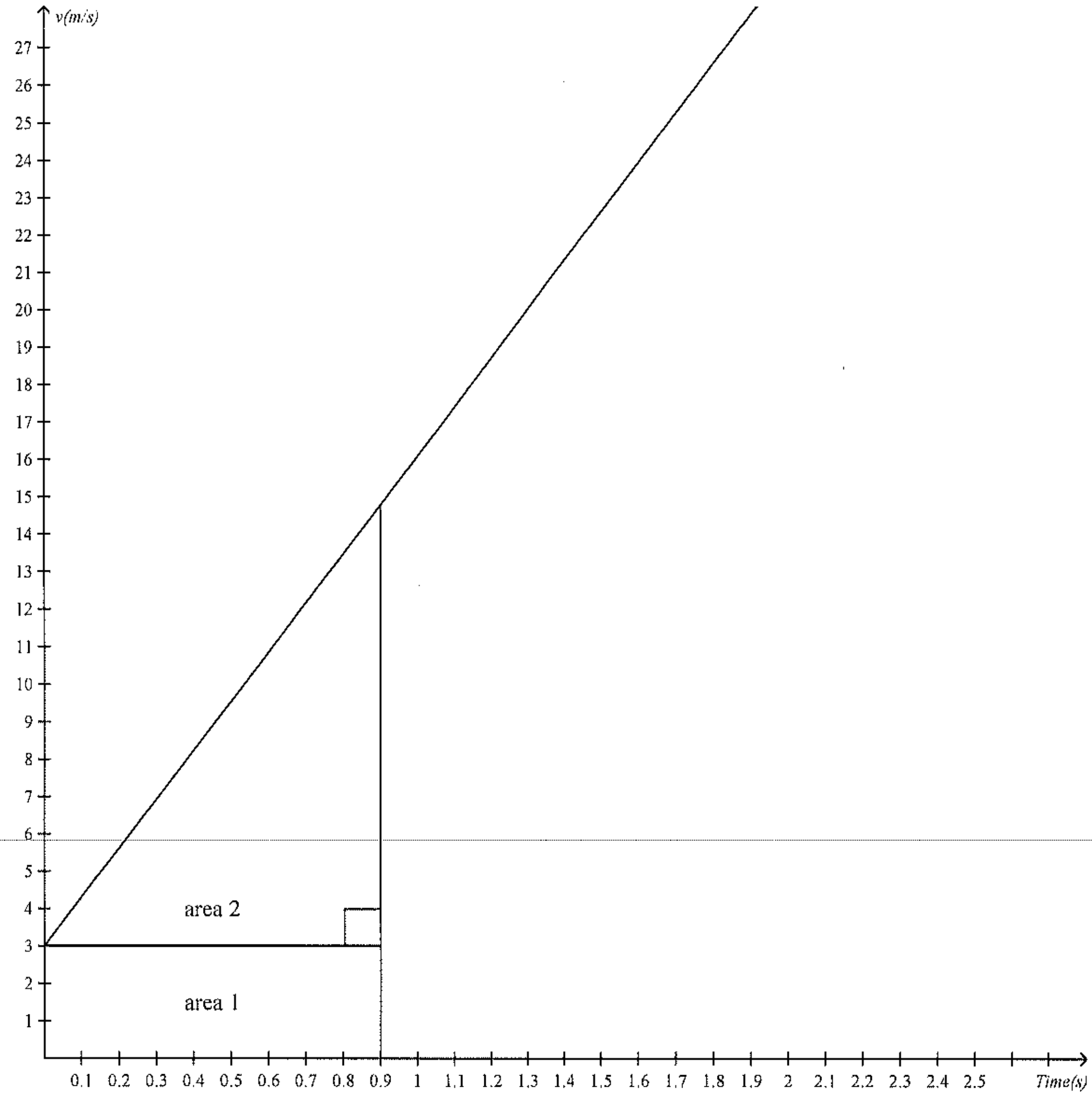
Area2 is $\frac{1}{2} \cdot time \cdot \left(v_f - v_i\right) = \frac{1}{2} \cdot 1.5s \cdot (11.05m/s - 4m/s) = 5.29m$

The total displacement is $6m + 5.29m = \underline{\underline{11.29m}}.$

b) Determine the acceleration of the object. **(1 mark)**

The acceleration of the object is found from the slope.

$$m = \frac{y_2 - y_1}{x_2 - x_1} = \underline{\underline{4.7m/s^2}}$$



43.

From the graph...

a) Determine the distance travelled up to time 0.9s. **(1 mark)**

ANSWER: (1 mark)

Area1 is $time \cdot velocity = 0.9s \cdot 3m/s = 2.7m.$

Area2 is $\frac{1}{2} \cdot time \cdot \left(v_f - v_i\right) = \frac{1}{2} \cdot 0.9s \cdot (14.79m/s - 3m/s) = 5.31m$

The total displacement is $2.7m + 5.31m = \underline{\underline{8.01m}}.$

b) Determine the average velocity of the object up to time 0.9s. **(1 mark)**

$$v_{average} = \frac{d_T}{t_T} = \frac{8.01m}{0.9s} = \underline{\underline{8.9\frac{m}{s}}}$$

44. Dejan leaves home at a velocity of 3.5 km/h. After travelling for 101 minutes, Dejan's friend races after Dejan at 7.5 km/h.

a) How long does it take for the friend to catch up to Dejan? **(2 marks)**

ANSWER: (2 marks)

headstart distance = velocity of person x length of headstart

Convert head start time into hours = $\frac{101\,\text{min}}{60\,\text{min}/h}$ =1.68 *hours*.

headstart distance = $3.5km/h \times 101h = 5.9km$

Calculate the relative velocity = friend's velocity - *Dejan*'s velocity $= 7.5km/h - 3.5km/h = 4km/h$

The time it takes to catch up is t= $\frac{\text{head start distance (km)}}{\text{relative velocity (km/h)}} = \frac{5.9km}{4km/h}$ = $\underline{\underline{1.47 hours = 88.4\,\text{min} = 5303s}}$

b) How far from home are they when Dejan is caught? **(1 mark)**

ANSWER: (1 mark)

The distance from home is d = friend's velocity x time to catch up = $7.5km/h \times 1.47h = 11.05km$

OR d = *Dejan*'s velocity x (time to catch up + head start time) $= 3.5km/h \times (1.47h + 1.68h) = \underline{\underline{11.05km}}$

45. Courtenay is 206 km from Comox. Train A leaves Courtenay at a velocity of 69 km/h. at 9 am. and train B leaves Comox at a velocity of 80 km/h also at 9 am.

a) At what time do they pass each other (to the nearest minute)? **(2 marks)**

ANSWER: (2 marks)

Calculate the relative velocity = Train A's velocity +Train B's velocity = $69km/h + 80km/h = 149km/h$

Determine how long it takes for the trains to pass each other.

time = $\frac{\text{distance the cities are apart}}{\text{relative velocity of the trains}} = \frac{206km}{149km/h}$ =1.38*hours*

Subtact $1h$ from $1.38h = 0.38 hours$

Convert decimal hours into minutes = $0.38 \times \frac{60\,\text{min}}{h}$ =23 min

Add the time it takes to the time they left the station at 9am+1 + 23

They pass each other at $\underline{\underline{10{:}23am}}$.

b) How far from Courtenay are both trains when they pass each other? **(1 mark)**

ANSWER: (1 mark)

The distance from *Courtenay* is = the time train A is travelling x the velocity of train A

$= 1.38h \times 69km/h = \underline{\underline{95.4km}}$

46. A car starts from rest and travels 200 km in 12.5 hrs. What is the average velocity? **(2 marks)**

ANSWER: (2 marks)

$d = 200$ km, $t = 12.5$ h, v_{avg} =? km/h

$d = vt \qquad v = \frac{d}{t} = \frac{200\text{ km}}{12.5\text{ h}} = \underline{\underline{16\text{ km/h}}}$

47. A car starts from rest and travels 425 km in 9 hrs. What is the average velocity? **(2 marks)**
ANSWER: (2 marks)
$d = 425$ km, $t = 9$ h, $v_{avg} =?$ km/h

$d = vt \qquad v = \frac{d}{t} = \frac{425 \text{ km}}{9 \text{ h}} = \underline{\underline{47.22 \text{ km/h}}}$

48. You are going on a 118 km road trip, if you start from rest and travel 47 km/h for 1.1 hours, then stop for a restroom break for 30 minutes, how fast do you need to drive for if you are to have an average velocity of 51 km/h for the entire trip? **(3 marks)**

ANSWER: (3 marks)
First, you need to determine how long the whole trip is? $\text{time}=\frac{\text{total distance}}{\text{average velocity}} = \frac{118km}{51km/h} = 2.31hours$

Second, you need to determine how far you travelled in the first trip?
$\text{distance}=\text{velocity} \times \text{time} = 47km/h \times 1.1hours = 51.7km$
Third, you need to determine how much of the total time you have left after driving and stopping?
time left = total time - time driving - time stopped(convert to hours by /60)
$= 2.31 - 1.1 - 30/60\,\text{min} = 0.7hours$
Fourth, you need to determine how far you still have to go? $= 118km - 51.7km = 66.3km$
Fifth, to find the velocity at which you need to complete the trip with an average velocity of 51km/h, just divide the remaining distance by the remaining time.
$= \frac{66.3km}{0.7hours} = \underline{\underline{92.89km/h}}$

49. You are going on a road trip. First you travel 42 km/h for 2.7 hours, then stop for a lunch break for 92 minutes. Then you drive again for 126km at 87km/h. What is your average velocity for the whole trip? **(3 marks)**

ANSWER: (3 marks)
First, you need to determine how far you went for the first trip.
$\text{first distance} = \text{velocity} \cdot \text{time} = 42km/h \cdot 2.7s = 113.4km$
Second, you need to determine how long you waited in hours?
$\frac{\text{breaktime minutes}}{60\,\text{min/hour}} = \frac{92\,\text{min}}{60\,\text{min/hour}} = 1.53hours$
Third, you need to determine how long you took for the third trip.
$\text{time of third trip} = \frac{\text{distance}}{\text{velocity}} = \frac{126km}{87km/h} = 1.45h$
Fourth, you need to determine how far you have driven and how long you have been on the road.
first distance + second distance = total distance

$113.4km + 126km = 239.4km$

time for first drive + time for break + time for second drive = total time

2.7h+1.53h+1.45h=5.68h
Finally, find the average velocity of the whole trip by dividing the total distance by the total time.
$\text{Average Velocity} = \frac{\text{Total Distance km}}{\text{Total Time hours}} = \frac{239.4km}{5.68h} = \underline{\underline{42.14km/h}}$

50. An astronaut breaks the Uranus high jump record by jumping to a height of 11.3m with a vertical jump of 7.6 m/s. What is the gravitational acceleration on the surface of Uranus? **(3 marks)**

ANSWER: (3 marks)
$v_i = 7.6m/s, \quad v_f = 0m/s, \quad d = 11.3m, \quad a = ?m/s^2$

$$\left(v_f\right)^2 = \left(v_i\right)^2 - 2ad \qquad a = \frac{\left(v_f\right)^2 - \left(v_i\right)^2}{2d} = \frac{0^2 m/s - (7.6m/s)^2}{(2)(11.3m)} = \underline{\underline{2.56m/s^2}}$$

51. What would an astronaut's initial velocity be is they could jump to a height of 14.9m on the Neptune. The gravitational acceleration on the surface of Neptune is $2m/s^2$? **(3 marks)**

ANSWER: (3 marks)
$v_f = 0m/s$ (max height), $\quad d = 14.9m, \quad a = 2m/s^2, \quad v_i = ?m/s$

$$\left(v_f\right)^2 = \left(v_i\right)^2 - 2ad \qquad v_i = \sqrt{\left(v_f\right)^2 - 2ad} = \sqrt{0 - 2(-2m/s^2)(14.9m)} = \underline{\underline{7.72m/s}}$$

52. A truck traveling at 64.7 m/s applies the brakes and slows down at a constant rate to 26.3 m/s in 387.3 meters.
How long does it take the truck to slow down? **(3 marks)**

ANSWER: (3 marks)
$v_i = 64.7m/s, \quad v_f = 26.3m/s, \quad d = 387.3m, \quad t = ?s$

$$d = \left(\frac{v_f + v_i}{2}\right)t \qquad t = \frac{2 \cdot d}{\left(v_f + v_i\right)} = \frac{2 \cdot 387.3m}{(26.3m/s + 64.7m/s)} = \underline{\underline{8.51s}}$$

53. A truck is travelling at 22m/s then it accelerates at a rate of $10m/s^2$ for 13s.
How far has it travelled in the time it was accelerating? **(3 marks)**

ANSWER: (3 marks)
$v_i = 22m/s, \quad a = 10m/s^2, \quad t = 13s, \quad d = ?m$

$$d = v_i t + \tfrac{1}{2}at^2 = 22m/s \cdot 13s + \tfrac{1}{2} \cdot 10m/s^2 \cdot (13s)^2 = \underline{\underline{1131m}}$$

54. How high do you have to be to drop a rock so that it hits the ground in 17.8 seconds? **(3 marks)**
ANSWER: (3 marks)
$v_i = 0m/s, \quad a = 9.8m/s^2, \quad t = 17.8s, \quad d = ?m$

$$d = v_i t + \tfrac{1}{2}at^2 = 0m/s \cdot 17.8s + \tfrac{1}{2} \cdot 9.8m/s^2 \cdot (17.8s)^2 = \underline{\underline{1552.52m}}$$

55. A ball is dropped off a building and 3.2 seconds later a second ball is thrown upwards at 3.2 m/s. How far apart are the balls when the second ball is moving at -19.6 m/s? **(3 marks)**

ANSWER: (3 marks)
First, find how long it takes for the second ball to reach it's final velocity of -19.6 m/s.
$v_{i_2} = 3.2 m/s, \quad v_{f_2} = -19.6 m/s, \quad a = -9.8 m/s^2, \quad t = ?s$ Second, find how far the second ball has

$$v_{f_2} = v_{i_2} + at \qquad t = \frac{v_{f_2} - v_{i_2}}{a} = \frac{-19.6 m/s - 3.2 m/s}{-9.8 m/s^2} = 2.33 s$$

fallen in that time.
$v_i = 3.2 m/s, \quad a = -9.8 m/s^2, \quad t = 2.33 s, \quad d = ?m$

$$d = v_i t + \tfrac{1}{2} at^2 = 3.2 m/s \times 2.33 s + \tfrac{1}{2}(-9.8 m/s^2)(2.33)^2 = -19.08 m$$

Third, find how far the first ball has fallen in the total time (headstart time + time of second object).
$v_{i_1} = 0 m/s, \quad a = -9.8 m/s^2, \quad t = 3.2 s + 2.33 s = 5.53 s, \quad d = ?m$

$$d = v_{i_1} t + \tfrac{1}{2} at^2 = \tfrac{1}{2}(-9.8 m/s^2)(5.53 s)^2 = -149.66 m$$

Finally, find the distance the two balls are apart.
$d_1 = -149.66 m, \quad d_2 = -19.08 m$

$$\text{distance apart} = |d_1 - d_2| = |-149.66 m - -19.08 m| = \underline{\underline{130.58 m}}$$

56. A physics book is dropped off a building and 4.8 seconds later a second physics book is thrown upwards at 4.3 m/s. How far apart are the physics books when the second physics book has fallen to -92 m? **(3 marks)**

ANSWER: (3 marks)
First, find fast the second physics book is moving when it reached -92m.

$v_{i_2} = 4.3m/s$

$d = -92m$

$a = -9.8m/s^2$

$v_{f_2} = m/s$

$\left(v_{f_2}\right)^2 = \left(v_{i_2}\right)^2 + 2ad$

$v_{f_2} = \sqrt{(4.3m/s)^2 + 2\left(-9.8m/s^2\right)(-92m)} = -42.7m/s$

We need to add the negative sign to the final velocity since the object is below the start point.
Second, find how long it has taken the second physics book to fall that distance.

$v_{i_2} = 4.3m/s$

$v_{f_2} = -42.7m/s$

$a = -9.8m/s^2$

$t = 4.79s$

$v_{f_2} = v_{i_2} + at$

$t = \dfrac{v_{f_2} - v_{i_2}}{a} = \dfrac{-42.7m/s - 4.3m/s}{-9.8m/s^2} = 4.79s$

Third, find how far the first physics book has fallen in the total time (headstart time + time of second object).

$v_{i_1} = 0m/s$

$t = 4.8s + 4.79s = 9.59s$

$a = -9.8m/s^2$

$d = ?m$

$d = v_i t + \frac{1}{2}at^2 = (0m/s)(9.59s) + \frac{1}{2}(-9.8m/s^2)(9.59s)^2 = -451.02m$

Finally, find the distance the two physics books are apart.

$d_1 = -451.02m$

$d_2 = -92m$

distance apart $= \left|d_1 - d_2\right| = |-451.02m - 92m| = \underline{\underline{359.02m}}$

57. A projectile is fired straight up with an initial velocity of 5.2 m/s. If air resistance is negligible, how much time elapses before the projectile reaches its maximum height? **(3 marks)**

ANSWER: (3 marks)

$v_f = 0\,m/s\,(\max height),\quad v_i = 5.2\,m/s,\quad a = -9.8\,m/s^2,\quad t = ?\,s$

$$v_f = v_i + at \qquad t = \frac{v_f - v_i}{a} = \frac{0m/s - 5.2m/s}{-9.8m/s^2} = \underline{\underline{0.53s}}$$

58. A boy is standing on the edge of a 32 m cliff and he throws a ball straight up with an initial velocity of 16.5 m/s. If air resistance is negligible, how fast is the ball moving when it is 6.6 m below the edge of the cliff? **(3 marks)**

ANSWER: (3 marks)

$v_i = 16.5\,m/s,\quad a = -9.8\,m/s^2,\quad d = -6.6m,\quad v_f = ?\,m/s$

$$\left(v_f\right)^2 = \left(v_i\right)^2 + 2ad \qquad v_f = \sqrt{\left(v_i\right)^2 + 2ad} = \sqrt{(16.5m/s)^2 + 2\cdot\left(-9.8\tfrac{m}{s^2}\right)\cdot(-6.6m)} = \underline{\underline{20.04m/s}}$$

59. A car traveling at 10 m/s speeds up going down a hill, and is moving at a rate of 47 m/s 34.5 seconds later.

a) What is the rate of acceleration? **(2 marks)**

ANSWER: (2 marks)

$v_i = 10m/s,\quad v_f = 47m/s,\quad t = 34.5s,\quad a = ?\,m/s^2$

$$v_f = v_i + at \qquad a = \frac{(v_f - v_i)}{t} = \frac{(47m/s - 10m/s)}{34.5s} = \underline{\underline{1.07m/s^2}}$$

b) How far has the car in traveled in the 34.5 seconds? **(2 marks)**

$v_i = 10m/s,\quad v_f = 47m/s,\quad t = 34.5s,\quad a = 1.07m/s^2$

Since you know all the variables, you can use any of the formulas that have 'd' in them.

$$(v_f)^2 = (v_i)^2 + 2ad \quad \text{OR} \quad d = \frac{\left(v_f + v_i\right)}{2}t \quad \text{OR} \quad d = v_i t + \frac{1}{2}at^2$$

$$d = \frac{(v_f)^2 - (v_i)^2}{2a} = \frac{(47m/s)^2 - (10m/s)^2}{2\cdot 1.07m/s^2} = \underline{\underline{983.25m}}$$

$$d = \frac{\left(v_f + v_i\right)}{2}t = \frac{(47m/s + 10m/s)}{2}\,34.5s = \underline{\underline{983.25m}}$$

$$d = v_i t + \frac{1}{2}at^2 = 10m/s\cdot 34.5s + \frac{1}{2}\cdot 1.07m/s^2\cdot(34.5s)^2 = \underline{\underline{983.25m}}$$

60. An archer standing on a 78 m high wall fires an arrow horizontally at a rate of 14 m/s. How close to the wall can the enemy get before getting hit in the toes by arrows? **(3 marks)**
ANSWER: (3 marks)
First we need to solve for t using $d_y = \frac{1}{2}at^2$

$d_y = -78m, \quad a = -9.8m/s^2, \quad t = ?s$

$d_y = \frac{1}{2}at^2 \qquad t = \sqrt{\frac{2 \cdot d_y}{a}} = \sqrt{\left(\frac{2 \cdot (-78m)}{-9.8m/s^2}\right)} = 3.99s$

Now we can determine the d_x by using $d_x = v_x \cdot t$

$t = 3.99s, \quad v_x = 14m/s, \quad d_x = ?m$

$d_x = v_x \cdot t = 14m/s \cdot 3.99s = \underline{\underline{55.86m}}$

61. A rock is thrown horizontally off a cliff of height 68 m at a velocity of 11 m/s. How far from the base of the cliff does it land? **(3 marks)**

ANSWER: (3 marks)
First we need to solve for t using $d_y = \frac{1}{2}at^2$

$d_y = -68m, \quad a = -9.8m/s^2, \quad t = ?s$

$d_y = \frac{1}{2}at^2 \qquad t = \sqrt{\frac{2 \cdot d_y}{a}} = \sqrt{\left(\frac{2 \cdot (-68m)}{-9.8m/s^2}\right)} = 3.73s$

Now we can determine the d_x by using $d_x = v_x \cdot t$

$t = 3.73s, \quad v_x = 11m/s, \quad d_x = ?m$

$d_x = v_x \cdot t = 11m/s \cdot 3.73s = \underline{\underline{40.98m}}$

62. A rock is thrown horizontally off a cliff at a velocity of 8 m/s. If it lands 35 m from the base of the cliff, how high is the cliff? **(3 marks)**

ANSWER: (3 marks)
First we need to solve for t using $d_x = v_x \cdot t$

$v_x = 8m/s, \quad d_x = 35m, \quad t = ?s$

$d_x = v_x \cdot t \quad t = \frac{d_x}{v_x} = \frac{35m}{8m/s} = 4.38s$

Now we can determine the d_y by using the formula $d_y = \frac{1}{2}at^2$

$a = -9.8m/s^2, \quad t = 4.38s, \quad d_y = -?m$

$d_y = \frac{1}{2}at^2 = \frac{1}{2}(-9.8m/s^2)(4.38s)^2 = -\underline{\underline{93.79m}}$

63. A rock is thrown horizontally off a cliff of height 100 m and lands 36m from the base of the cliff. How fast was it moving when it was thrown off the cliff? **(3 marks)**

ANSWER: (3 marks)

First we need to solve for t using $d_y = \frac{1}{2}at^2$

$d_y = -100m, \quad a = -9.8m/s^2, \quad t = ?s$

$$d_y = \frac{1}{2}at^2 \qquad t = \sqrt{\frac{2 \cdot d_y}{a}} = \sqrt{\left(\frac{2 \cdot (-100m)}{-9.8m/s^2}\right)} = 4.52s$$

Now we can determine the v_x by using $d_x = v_x \cdot t$

$t = 4.52s, \quad d_x = 36m, \quad v_x = ?m/s$

$$d_x = v_x \cdot t \qquad v_x = \frac{d_x}{t} = \frac{36m}{4.52s} = \underline{\underline{7.97m/s}}$$

64. A prisoner wants to jump over the 4.9 m fence that is 5 m away from the edge of the 10 m high prison building. What is the minimum velocity the prisoner needs to run to just clear the fence? **(3 marks)**

ANSWER: (3 marks)

First we need to solve for t using $d_y = \frac{1}{2}at^2$

$d_y = -(10 - 4.9)m, \quad a = -9.8m/s^2, \quad t = ?s$

$$d_y = \frac{1}{2}at^2 \qquad t = \sqrt{\frac{2 \cdot d_y}{a}} = \sqrt{\left(\frac{2 \cdot (-5.1m)}{-9.8m/s^2}\right)} = 1.02s$$

Now we can determine the v_x by using $d_x = v_x \cdot t$

$t = 1.02s, \quad d_x = 5m, \quad v_x = ?m/s$

$$d_x = v_x \cdot t \qquad v_x = \frac{d_x}{t} = \frac{5m}{1.02s} = \underline{\underline{4.9m/s}}$$

b) What is the prisoner's vertical velocity when he hits the ground? **(2 marks)**

$d_y = -10m, \quad a = -9.8m/s^2, \quad v_i = 0m/s, \quad v_f = ?m/s$

$$\left(v_f\right)^2 = \left(v_i\right)^2 + 2ad_y = (0m/s)^2 + 2 \cdot \left(-9.8m/s^2\right) \cdot (-10m) = \sqrt{2 \cdot \left(-9.8m/s^2\right) \cdot (-10m)} = \underline{\underline{14m/s}}$$

65. A prisoner who can run at 6.7m/s, wants to jump over the 3.3 m fence that is 7 m away from the edge of a prison building.
a) What is the minimum height the building needs to be so the prisoner will just clear the fence? **(3 marks)**
ANSWER: (3 marks)
First we need to solve for t using $= t$

$d_x = 7m, \quad v_x = 6.7m/s, \quad t = ?s$

$$t = \frac{d_x}{v_x} = 1.04s$$

Now we can determine the d_y by using $d_y = \frac{1}{2}at^2$

$a = -9.8m/s^2, \quad t = 1.04s$

$$d_y = \frac{1}{2}at^2 = \frac{1}{2}\left(-9.8m/s^2\right)(1.04s)^2 = -5.35m$$

Now add the height to the fence height to get the height of the prison building.

prison building $= (5.35m + 3.3m) = \underline{\underline{8.65m}}$

b) What is the prisoner's vertical velocity when he hits the ground? **(2 marks)**
$d_y = -8.65m, \quad a = -9.8m/s^2, \quad v_i = 0m/s, \quad v_f = ?m/s$

$$\left(v_f\right)^2 = \left(v_i\right)^2 + 2ad_y = (0m/s)^2 + 2\cdot\left(-9.8m/s^2\right)\cdot(-8.65m) = \sqrt{2\cdot\left(-9.8m/s^2\right)\cdot(-8.65m)} = \underline{\underline{13.02m/s}}$$

66. Mr. Roome is dropping water-balloons on students as they pass under an over-head-walkway.
If he is 14 m above the student's heads and they are walking at a rate of 4.5 m/s, at what horizontal distance before the students pass underneath, should he drop the balloons to get a head-shot? **(3 marks)**

ANSWER: (3 marks)
First we need to solve for t using $d_y = \frac{1}{2}at^2$

$d_y = -14m, \quad a = -9.8m/s^2, \quad t = ?s$

$$d_y = \frac{1}{2}at^2 \qquad t = \sqrt{\frac{2\cdot d_y}{a}} = \sqrt{\left(\frac{2\cdot(-14m)}{-9.8m/s^2}\right)} = 1.69s$$

Now we can determine the d_x by using $d_x = v_x \cdot t$

$t = 1.69s, \quad v_x = 4.5m/s, \quad d_x = ?m$

$d_x = v_x \cdot t = 4.5m/s \cdot 1.69s = \underline{\underline{7.61m}}$

67. An airplane is flying along at 250 km/h and at an altitude of 950 m. An enemy tank is moving towards the plane at 50 km/h. How far from the tank (directly below the plane) should the plane drop the bomb so it hits the tank? **(3 marks)**

ANSWER: (3 marks)

First, determine the time it takes for the bomb to hit the ground.

$$d_y = -950m, \quad a = -9.8m/s^2, \quad t = ?s$$

$$d_y = \frac{1}{2}at^2 \qquad t = \sqrt{\frac{2d_y}{a}} = \sqrt{\frac{2\cdot -950m}{-9.8m/s^2}} = \underline{\underline{13.92s}}$$

Second, determine how far the bomb travels in 13.92s.

$$v_{plane} = 250km/h = 69.44m/s, \quad t = 13.92s, \quad d_{bomb} = ?m$$

$$d_{bomb} = v_{bomb} \cdot time = 69.44m/s \cdot 13.92s = 966.94m$$

Third, determine how far the tank travels in 13.92s.

$$v_{\tan k} = 50km/h = 13.89m/s, \quad t = 13.92s, \quad d_{\tan k} = ?m$$

$$d_{\tan k} = v_{\tan k} \cdot time = 13.89m/s \cdot 13.92s = 193.39m$$

Finally, determine the distance away from tank to drop the bomb. Because the tank is moving towards the plane, we have to drop the bomb earlier so the distance is farther.

$$d_{drop} = d_{bomb} + d_{\tan k} = 966.94m + 193.39m = \underline{\underline{1,160.33m}}$$

68. An airplane is flying along at 230 km/h and at an altitude of 3800 m. An enemy tank is moving in the same direction as the plane at 35 km/h. How far from the tank (directly below the plane) should the plane drop the bomb so it hits the tank? **(3 marks)**
ANSWER: (3 marks)
First, determine the time it takes for the bomb to hit the ground.

$d_y = -3800m, \quad a = -9.8m/s^2, \quad t = ?s$

$$d_y = \frac{1}{2}at^2 \qquad t = \sqrt{\frac{2d_y}{a}} = \sqrt{\frac{2 \cdot -3800m}{-9.8m/s^2}} = \underline{\underline{27.85s}}$$

Second, determine how far the bomb travels in 27.85s.

$v_{plane} = 230km/h = 63.89m/s, \quad t = 27.85s, \quad d_{bomb} = ?m$

$d_{bomb} = v_{bomb} \cdot time = 63.89m/s \cdot 27.85s = 1,779.18m$

Third, determine how far the tank travels in 27.85s.

$v_{\tan k} = 35km/h = 9.72m/s, \quad t = 27.85s, \quad d_{\tan k} = ?m$

$d_{\tan k} = v_{\tan k} \cdot time = 9.72m/s \cdot 27.85s = 270.74m$

Finally, determine the distance away from tank to drop the bomb. Because the tank is moving in the same direction as the plane, we have to drop the bomb later so the distance is closer.

$d_{drop} = d_{bomb} - d_{\tan k} = 1,779.18m - 270.74m = \underline{\underline{1,508.43m}}$

69. What is the gravitational acceleration of a planet if an astronaut runs at a rate of 4.7 m/s off a 31 m hill and lands 5 m from the base of the hill? **(3 marks)**
ANSWER: (3 marks)
First, find how long it takes to travel 5m at a rate of 4.7m/s.

$v_x = 4.7m/s, \quad d_x = 5m$

$$d_x = v_x t \qquad t = \frac{d_x}{v_x} = \frac{5m}{4.7m/s} = 1.06s$$

Now, determine the acceleration due to gravity.

$d_y = 31m, \quad t = 1.06s, \quad a = ?m/s^2$

$$d_y = \frac{1}{2}at^2 \qquad a = \frac{2 \cdot d_y}{t^2} = \frac{2 \cdot 31m}{(1.06s)^2} = \underline{\underline{54.78m/s^2}}$$

70. How high is a building if a runner running at 5.5 m/s can land 13.5 m from the base of the building (ignore broken bones or death upon landing)? **(3 marks)**

ANSWER: (3 marks)

First, find how long it takes to travel 13.5m at a rate of 5.5m/s.

$v_x = 5.5m/s, \quad d_x = 13.5m$

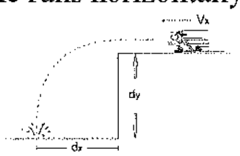
$d_x = v_x t \qquad t = \dfrac{d_x}{v_x} = \dfrac{13.5m}{5.5m/s} = 2.45s$

Now, determine the height of the building.

$t = 2.45s, \quad a = -9.8m/s^2, \quad d_y = ?\,m$

$d_y = \frac{1}{2}at^2 = \frac{1}{2}(-9.8m/s^2)(2.45s)^2 = \underline{\underline{29.52m}}$ (ignore the negative as we are looking for height)

71. Mike runs horizontally off a cliff at 5.8 m/s and lands in the water 17.5 m from the base of the cliff.



a) How long does it take Mike to hit the water? **(1 mark)**

ANSWER: (1 mark)

$d_x = 17.5m, \quad v_x = 5.8m/s, \quad t = ?\,s$

$d_x = v_x t \qquad t = \dfrac{d_x}{v_x} = \dfrac{17.5m}{5.8m/s} = \underline{\underline{3.02s}}$

b) How high is the cliff? **(2 marks)**

$d_y = ?\,m, \quad v_{yi} = 0m/s, \quad t = 3.02s, \quad a = -9.8m/s^2$

$d_y = v_{yi}t + \frac{1}{2}at^2 \qquad d_y = (0m/s)(3.02s) + \frac{1}{2}(-9.8m/s^2)(3.02s)^2 = \underline{\underline{44.61m}}$

72. If a car weighs 4,470 N on Pluto (gravitational field strength of 0.23 N/kg), what is its weight on Jupiter if the gravitational field strength of Jupiter is 26.85 N/kg. **(2 marks)**

ANSWER: (2 marks)

First, find the mass in kg of the first object on that planet.

$W = F_g = mg$

$m = \dfrac{F_g}{g} = \dfrac{4{,}470N}{0.23N/kg} = 19{,}434.78kg$

The mass will be the same on both planets, so use the same formula to find the new weight.

$W = F_g = mg$

$F_g = mg = 19{,}434.78kg \cdot 26.85N/kg = \underline{\underline{521{,}823.91N}}$

73. What is the normal force acting on a 7 kg computer sitting on a table if a person is pushing the computer down with a 20.5 N force? **(3 marks)**

ANSWER: (3 marks)

$F_{net} = ma$

$-F_a - F_g + F_N = 0$

$F_N = F_g + F_a$

$F_N = m \cdot g + F_a$

$F_N = 7kg \cdot 9.8N/kg + 20.5N = \underline{\underline{89.1N}}$

74. An elevator is accelerating upwards at a rate of 7.4 m/s^2. A 88 kg person is standing on a scale inside the elevator. What is the reading on the scale? **(3 marks)**

ANSWER: (3 marks)

$F_{net} = ma$

$-F_g + F_N = m(+a)$

$F_N = +ma + mg$

$F_N = +88kg \cdot 7.4m/s^2 + 88kg \cdot 9.8m/s^2 = \underline{\underline{1{,}513.6N}}$

75. What is the coefficient of friction on a 17 kg object that takes 180.4 N of applied force to accelerate it at a rate of 9.2 m/s^2?

ANSWER: (3 marks)

$F_{net} = ma$

$-F_f + F_a = ma$

$-\mu mg + F_a = ma$

$$\mu = \frac{F_a - ma}{mg} = \frac{180.4N - 17kg \cdot 9.2m/s^2}{17kg \cdot 9.8m/s^2} = \underline{\underline{0.144}}$$

76. What is the mass of a block if it stretches a spring 1.6 m with a spring constant of 67 N/m, while pulling a block along at a constant velocity of 3 m/s over a floor with a coefficient of ▯ = 1.2 ? **(3 marks)**

ANSWER: (3 marks)

$F_{net} = ma$

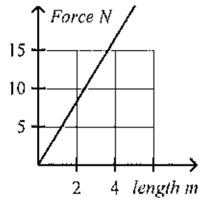
$-F_f + F_{spring} = m(0)$ {constant velocity, so $a = 0m/s^2$}

$F_f = F_{spring}$

$\mu \cdot m \cdot g = k \cdot x$

$$m = \frac{k \cdot x}{\mu \cdot g} = \frac{67N/m \cdot 1.6m}{1.2 \cdot 9.8m/s^2} = \underline{\underline{9.12kg}}$$

77. If I applied a force of 153 N to the spring represented in the graph below, how far would it stretch? (There is no elastic limit on this very long spring) **(3 marks)**



ANSWER: (3 marks)

First we need to find the slope of the graph which gives up the spring constant. **(2 marks)**

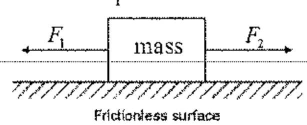
$$m = \frac{y_2 - y_1}{x_2 - x_1} = 4.1N/m$$

Next we use the spring constant with the applied force to find distance. (1 mark)

$$F_S = kx$$

$$x = \frac{F_S}{k} = \frac{153N}{4.1N/m} = \underline{\underline{37.32m}}$$

78. Two forces are applied to a 17 kg block on a frictionless horizontal surface (▯=0), as shown in the diagram below. $F_1 = 1N$ and $F_2 = 19N$



What is the acceleration of the block and in what direction [left or right]? **(3 marks)**

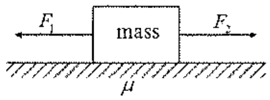
ANSWER: (3 marks)

$$F_{net} = ma$$

$$-F_1 + F_2 = ma$$

$$a = \frac{-F_1 + F_2}{m} = \frac{-1N + 19N}{17kg} = \underline{\underline{1.06m/s^2 right}}$$

79. Two forces are applied to a 1 kg block on a horizontal surface (=0.4), as shown in the diagram below.
$F_1 = 12N$ and $F_2 = 16N$



What is the acceleration of the block and in what direction [left or right]? **(3 marks)**
Hint: Determine the direction of movement before you apply the force of friction.

ANSWER: (3 marks)
First, determine the direction the block will move by seeing which for is larger.

If $F_1 < F_2$ then F_f will be acting to the left (opposing the motion to the right).

If $F_1 > F_2$ then F_f will be acting to the right (opposing the motion to the left).

Since $F_1 < F_2$, then F_f will be "$-$" $\left(left\right)$.

$F_f = \mu mg = 0.4 \cdot 1kg \cdot 9.8m/s^2 = 3.92N$

$F_{net} = ma$

$-F_1 + F_2 - F_f = ma$

$-F_1 + F_2 - \mu mg = ma$

$$a = \frac{-F_1 + F_2 - \mu mg}{m} = \frac{-12N + 16N - 0.4 \cdot 1kg \cdot 9.8m/s^2}{1kg} = \frac{F_{net}}{m} = \frac{-0.08N}{1kg} = \underline{\underline{-0.08m/s^2}}$$

80. A 88 kg water-skier is accelerated from rest to 14.7 m/s in 2.7 s. If the force of kinetic friction between the skiis and the water surface is 3,676 N, calculate the force of tension in the rope that pulled the skier. **(3 marks)**

ANSWER: (3 marks)
First find the acceleration of the water-skier.

$v_i = 0m/s$

$v_f = 14.7m/s$

$t = 2.7s$

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

$v_f = v_i + at$

$$a = \frac{v_f - v_i}{t} = \frac{14.7m/s - 0m/s}{2.7s} = 5.44m/s^2$$

Second, find the tension of the rope

$F_{net} = ma$

$-F_f + T = ma$

$T = ma + F_f$

$T = 88kg \cdot 5.44m/s^2 + 3{,}676N = \underline{\underline{4{,}155.11N}}$

81. What is the maximum acceleration of a 51 kg astronaut on Jupiter (g= 7.6 N/kg) can ascend a rope if it has a breaking strength of 472 N? **(3 marks)**

ANSWER: (3 marks)

$F_{net} = ma$

$T - F_g = ma$

$$a = \frac{T - F_g}{m} = \frac{T - mg}{m} = \frac{472N - 51kg \cdot 7.6N/kg}{51kg} = \underline{\underline{1.65m/s^2}}$$

82. What is the mass of an object that is accelerated at a rate of 4.5 m/s^2 across a floor that has a coefficient of friction =0.3 when a force of 167 N is applied to the object? **(3 marks)**

ANSWER: (3 marks)

$F_{net} = ma$

$-F_f + F_a = ma$

$-\mu mg + F_a = ma$

$F_a = ma + \mu mg$

$F_a = m(a + \mu g)$

$$m = \frac{F_a}{(a+\mu g)} = \frac{167N}{(4.5m/s^2 + 0.3 \cdot 9.8m/s^2)} = \underline{\underline{22.45kg}}$$

83. A block of wood of mass 27 kg sliding along a frozen lake at velocity 31 m/s slides onto a rough part of the ice, which exerts a 89 N frictional force on the block of wood.

a. What is the acceleration of the block of wood? **(2 marks)**

ANSWER: (2 marks)

$F_{net} = ma$

$-F_f = ma$

$$a = \frac{-F_f}{m} = \frac{-89N}{27kg} = \underline{\underline{-3.3m/s^2}}$$

b. How long does it take the block of wood to stop? **(2 marks)**

ANSWER: (2 marks)

$v_f = 0m/s$

$v_i = 31m/s$

$a = 3.3m/s^2$

$v_f = v_i + at$

$$t = \frac{v_f - v_i}{a} = \frac{0m/s - 31m/s}{-3.3m/s^2} = \underline{\underline{9.4s}}$$

84. If the coefficient of friction between rubber tires and asphalt is []=0.6. How much distance is needed in order to stop a 740 kg car going at 54 m/s? **(3 marks)**

ANSWER: (3 marks)
First, determine the deceleration caused by the force of friction.

$$F_{net} = ma$$

$$-F_f = ma$$

$$a = \frac{-F_f}{m} = \frac{-\mu \cdot m \cdot g}{m} = \frac{-0.6 \cdot 740kg \cdot 9.8m/s^2}{740kg} = \frac{-4351.2N}{740kg} = -5.88m/s^2$$

Second, determine the distance travelled using kinematics.

$$v_i = 54m/s$$

$$v_f = 0m/s$$

$$a = -5.88m/s^2$$

$$d = ?m$$

$$\left(v_f\right)^2 = \left(v_i\right)^2 + 2ad$$

$$d = \frac{\left(v_f\right)^2 - \left(v_i\right)^2}{2a} = \frac{(0m/s)^2 - (54m/s)^2}{2 \cdot 5.88m/s^2} = \underline{\underline{247.96m}}$$

85. A driver in a 2160 kg car is driving along at a rate of 39 m/s. If they see a child run out in front of the car 144 m away, what is the minimum coefficient of friction needed to stop the car before it hits the child? **(3 marks)**

ANSWER: (3 marks)
First, determine the deceleration needed in order to stop the car in time.

$v_i = 39m/s$

$v_f = 0m/s$

$d = 144m$

$a = ?m/s^2$

$$\left(v_f\right)^2 = \left(v_i\right)^2 + 2ad$$

$$a = \frac{\left(v_f\right)^2 - \left(v_i\right)^2}{2d} = \frac{(0m/s)^2 - (39m/s)^2}{2 \cdot 144m} = \underline{\underline{-5.28m/s^2}}$$

Second, determine the force of friction needed to create that deceleration.

$F_{net} = ma$

$-F_f = ma$

$-\mu \cdot m \cdot g = m \cdot a$

$$\mu = -\frac{m \cdot a}{m \cdot g} = -\frac{2160kg \cdot 5.28m/s^2}{2160kg \cdot 9.8m/s^2} = \underline{\underline{0.539}}$$

86. The radius of Mercury is about 2,440 km and it's mass is 3.3×10^{23} kg. What would be the Mercury's gravitational force of attraction on a 109 kg astronaut in an orbit 6,680 km **above** the Mercury's surface? **(3 marks)**

ANSWER: (3 marks)
Don't forget to convert your radius and height above surface into meters!

$$F_g = \frac{Gm_1m_2}{d^2} = \frac{6.67 \times 10^{-11} \frac{N \cdot m^2}{kg^2} \cdot 109kg \cdot 3.3e+023kg}{(2{,}440{,}000m + 6{,}680{,}000m)^2} = \underline{\underline{28.85N}}$$

87. The mass of the Moon is about 7.0×10^{22} kg, and it's radius is 1,739 km. What is the acceleration due to gravity on the surface of the Moon?**(3 marks)**

ANSWER: (3 marks)

$$F_g = \not{m}g = \frac{G\not{m}M_P}{\left(r_P\right)^2}$$

$$g = \frac{GM_P}{\left(r_P\right)^2} = \frac{6.67\times 10^{-11}\,\frac{N\cdot m^2}{kg^2}\cdot 7.0e+022kg}{\left(1{,}739{,}000m\right)^2} = \underline{\underline{1.544m/s^2}}$$

88. The mass of the Moon is about 7.0×10^{22}, and the acceleration due to gravity is $1.54m/s^2$. What is the radius of planet in kilometers? **(3 marks)**

ANSWER: (3 marks)

$$F_g = \not{m}g = \frac{G\not{m}M_P}{\left(r_P\right)^2}$$

$$\left(r_P\right)^2 = \frac{G\cdot M_P}{g}$$

$$r_P = \sqrt{\frac{G\cdot M_P}{g}} = \sqrt{\frac{6.67\times 10^{-11}\,\frac{N\cdot m^2}{kg^2}\cdot 7.0e+022kg}{1.54m/s^2}} = 1.741e+006m = \frac{1.741e+006m}{1000m/km} = \underline{\underline{1{,}741km}}$$

89. A force of 139 N is required to pull a 26 kg wooden block at a constant velocity across a smooth glass surface on Uranus (mass=8.7×10^{25} kg, radius=25,050 km). What force would be required to pull the same wooden block across the same glass surface of Neptune (mass=1×10^{26} kg, radius=24700 km) at a constant velocity? **(4 marks)**

ANSWER: (4 marks)
First, find the coefficient of friction of the block on the glass on the first planet.

$$F_{net} = ma$$

$$-F_f + F_a = m(0) \quad \{\text{constant velocity so } a = 0m/s^2\}$$

$$F_a = F_f = \mu \cdot m \cdot g$$

$$g = \frac{G \cdot m_P}{\left(r_P\right)^2} = \frac{6.67 \times 10^{-11} \frac{N \cdot m^2}{kg^2} \cdot 8.7e+025kg}{\left(25{,}050{,}000m\right)^2} = 9.25m/s^2$$

$$F_a = \mu \cdot m \cdot g$$

$$\mu = \frac{F_a}{m \cdot g} = \frac{139N}{26kg \cdot 9.25m/s^2} = 0.58$$

Second, find the force needed to pull the block at a constant velocity using the coefficient of friction.

$$F_{net} = ma$$

$$-F_f + F_a = m(0) \quad \{\text{constant velocity so } a = 0m/s^2\}$$

$$F_a = F_f = \mu \cdot m \cdot g$$

$$g = \frac{G \cdot m_P}{\left(r_P\right)^2} = \frac{6.67 \times 10^{-11} \frac{N \cdot m^2}{kg^2} \cdot 1.03e+026kg}{\left(24{,}700{,}000m\right)^2} = 11.26m/s^2$$

$$F_a = \mu \cdot m \cdot g = 0.58 \cdot 26kg \cdot 11.26m/s^2 = \underline{\underline{169.26N}}$$

90. A force of 32 N is required to pull a 21 kg wooden block at a constant velocity across a smooth glass surface on Venus (mass=4.87×10^{24} kg, radius=6,050 km). What force would be required to pull the same wooden block across the same glass surface of Mars (mass=6×10^{23} kg, radius=3394 km) with an acceleration of $8m/s^2$? **(4 marks)**

ANSWER: (4 marks)
First, find the coefficient of friction of the block on the glass on the first planet.

$$F_{net} = ma$$

$$-F_f + F_a = m(0) \quad \{\text{constant velocity so } a = 0m/s^2\}$$

$$F_a = F_f = \mu \cdot m \cdot g$$

$$g = \frac{G \cdot m_p}{\left(r_p\right)^2} = \frac{6.67\times 10^{-11}\,\frac{N\cdot m^2}{kg^2} \cdot 4.87e+024kg}{\left(6{,}050{,}000m\right)^2} = 8.87m/s^2$$

$$F_a = \mu \cdot m \cdot g$$

$$\mu = \frac{F_a}{m\cdot g} = \frac{32N}{21kg \cdot 8.87m/s^2} = 0.17$$

Second, find the force needed to pull the block at a constant velocity using the coefficient of friction.

$$F_{net} = ma$$

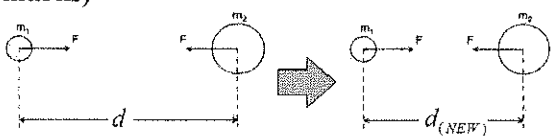
$$-F_f + F_a = ma$$

$$F_a = ma + F_f = m\cdot a + \mu \cdot m \cdot g$$

$$g = \frac{G \cdot m_p}{\left(r_p\right)^2} = \frac{6.67\times 10^{-11}\,\frac{N\cdot m^2}{kg^2} \cdot 6.4e+023kg}{\left(3{,}394{,}000m\right)^2} = 3.71m/s^2$$

$$F_a = m\cdot a + \mu \cdot m \cdot g = 21kg \cdot 8m/s^2 + 0.17 \cdot 21kg \cdot 3.71m/s^2 = \underline{181.36N}$$

91. Two masses exert a force of 10 N on each other. They are originally at a distance 'd' apart, and are brought 4 times closer to each other. How much has the force between the two masses increased or decreased? **(2 marks)**



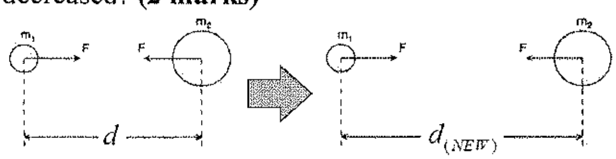
ANSWER: (2 marks)

$$F = \frac{Gm_1 m_2}{d^2}$$

$$F \propto \frac{1}{d^2}$$

$$F \propto \frac{1}{\left(\frac{1}{4}d\right)^2} = \frac{1}{\frac{1}{16}d^2} = 16 \times \frac{1}{d^2} = 16 \times F = 16 \times 10N = \underline{\underline{160N}}$$

92. Two masses exert a force of 70 N on each other. They are originally at a distance 'd' apart, and are pulled 10 times farther apart from each other. How much has the force between the two masses increased or decreased? **(2 marks)**



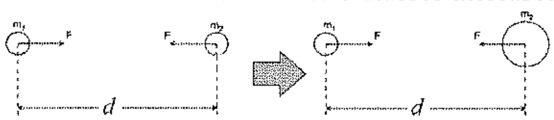
ANSWER: (2 marks)

$$F = \frac{Gm_1 m_2}{d^2}$$

$$F \propto \frac{1}{d^2}$$

$$F \propto \frac{1}{(10d)^2} = \frac{1}{100d^2} = \frac{1}{100} \times \frac{1}{d^2} = 0.01 \times F = 0.01 \times 70N = \underline{\underline{0.7N}}$$

93. Two masses exert a force of 200 N on each other. The second mass increases in size by 9 times. How much has the force between the two masses increased or decreased? **(2 marks)**



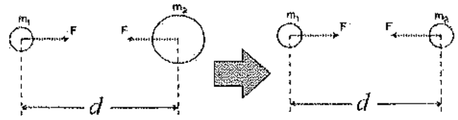
ANSWER: (2 marks)

$$F = \frac{Gm_1 m_2}{d^2}$$

$$F \propto m_2$$

$$F \propto 9m_2 = 9 \times 200N = \underline{\underline{1800N}}$$

94. Two masses exert a force of 60 N on each other. The second mass decreases in size by 9 times. How much has the force between the two masses increased or decreased? **(2 marks)**



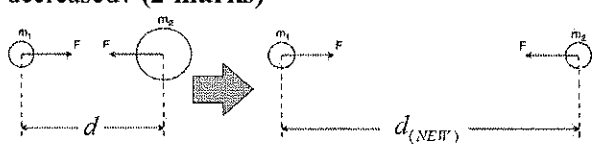
ANSWER: (2 marks)

$$F = \frac{Gm_1 m_2}{d^2}$$

$$F \propto m_2$$

$$F \propto \frac{1}{9} m_2 = 0.111 \times 60N = \underline{\underline{6.67N}}$$

95. Two masses exert a force of 440 N on each other. The distance between them has increased by 10 times and the second mass decreased in size by 6 times. How much has the force between the two masses increased or decreased? **(2 marks)**



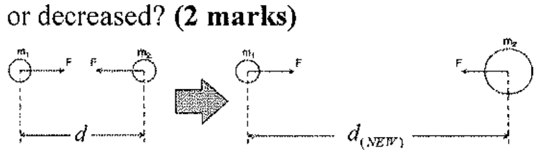
ANSWER: (2 marks)

$$F = \frac{Gm_1 m_2}{d^2}$$

$$F \propto \frac{m_2}{d^2}$$

$$F \propto \frac{m_2}{d^2} = \frac{\frac{m_2}{6}}{(10 \times d)^2} = \frac{1}{6 \cdot 10^2} \times \frac{m_2}{d^2} = \frac{1}{600} \times 440N = \underline{\underline{0.73N}}$$

96. Two masses exert a force of 920 N on each other. The distance between them has increased by 4 times and the second mass increased in size by 7.5 times. How much has the force between the two masses increased or decreased? **(2 marks)**



ANSWER: (2 marks)

$$F = \frac{Gm_1 m_2}{d^2}$$

$$F \propto \frac{m_2}{d^2}$$

$$F \propto \frac{m_2}{d^2} = \frac{7.5 \times m_2}{(4 \times d)^2} = \frac{7.5}{4^2} \times \frac{m_2}{d^2} = 0.47 \times 920N = \underline{\underline{431.25N}}$$

97. A boy on a bicycle drags a wagon full of newspapers at 10 m/s for 61 minutes using a force of 90 N. How much work has the boy done? **(3 marks)**

ANSWER: (3 marks)

$$d = v \cdot t = 10m/s \cdot 61m \times \frac{60s}{1m} = 36,600m$$

$$W = F \cdot d = 90N \cdot 36,600m = \underline{\underline{3,294,000J}}$$

98. A boy on a bicycle pushes with 22 N on the peddles while doing 184,400 J of work. He rides for 25 minutes. What is his average velocity for the 25 minutes? **(3 marks)**

ANSWER: (3 marks)

$$W = F \cdot d$$

$$d = \frac{W}{F} = \frac{184,400J}{22N} = 8,381.82m$$

$$d = v \cdot t$$

$$v = \frac{d}{t} = \frac{8,381.82m}{25m \times \frac{60s}{1m}} = \underline{\underline{5.59m/s}}$$

99. A boy on a bicycle pushes with 14 N on the peddles while doing 94,300 J of work. If he is riding a speed of 5.5 m/s, then how long has he been riding in minutes? **(3 marks)**

ANSWER: (3 marks)

$$W = F \cdot d$$

$$d = \frac{W}{F} = \frac{94,300J}{14N} = 6,735.71m$$

$$d = v \cdot t$$

$$t = \frac{d}{v} = \frac{6,735.71m}{5.5m/s} = 1,224.7s \times \frac{1m}{60s} = \underline{\underline{20.41m}}$$

100. If a boy on a bicycle riding at a constant velocity does 70,100 J in 70 minutes and he has applied 36 N during that time then how far has he ridden? **(3 marks)**

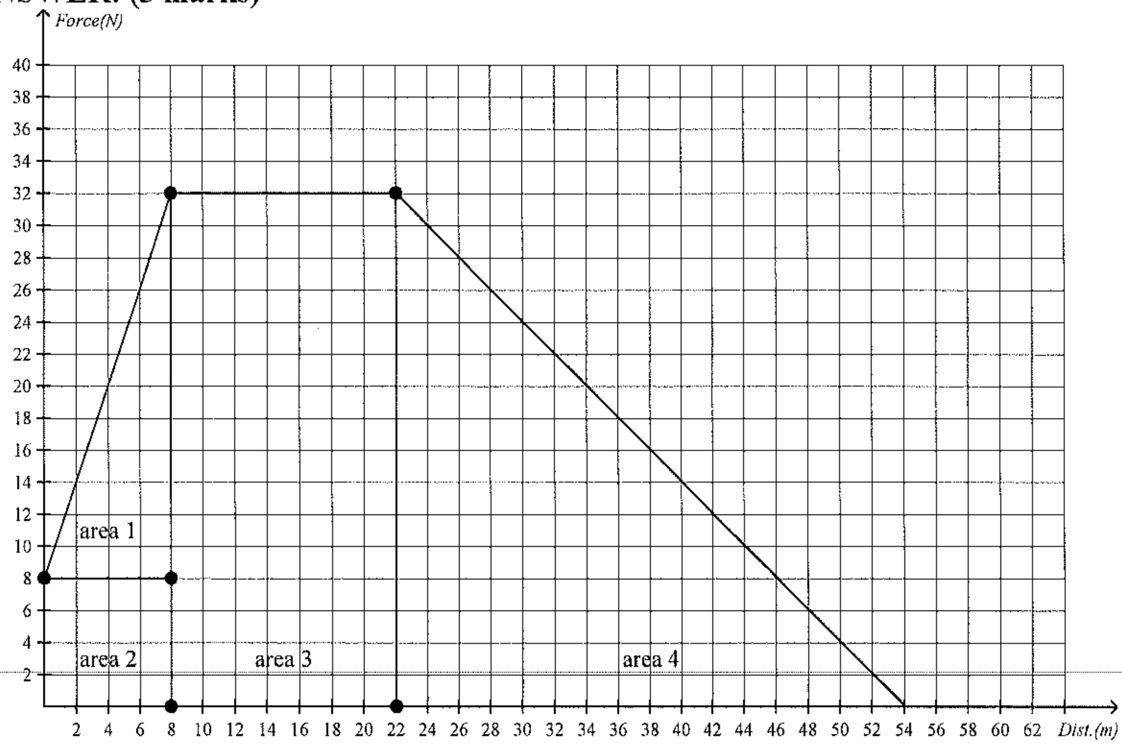
ANSWER: (3 marks)

$$W = F \cdot d$$

$$d = \frac{W}{F} = \frac{70,100J}{36N} = \underline{\underline{1,947.22m}}$$

101. The graph below shows the force applied to an 14 kg object over a total distance of 54 m. The object is already moving at a velocity of 4 m/s. How fast is the 14 kg object moving after being pushed for 54 meters? (no marks if solved by using kinematics and dynamics) **(3 marks)**

ANSWER: (3 marks)



$$area_1 = \frac{1}{2} \cdot b \cdot h = \frac{1}{2} \cdot 8m \cdot (32N - 8N) = 96J$$

$$area_2 = b \cdot h = 8m \cdot 8N = 64J$$

$$area_3 = b \cdot h = (22m - 8m) \cdot 32N = 448J$$

$$area_4 = \frac{1}{2} \cdot b \cdot h = \frac{1}{2} \cdot (54m - 22m) \cdot 32N = 512J$$

$$area_{total} = area_1 + area_2 + area_3 + area_4 = 96J + 64J + 448J + 512J = \underline{\underline{1120J}}$$

$$area = work = \Delta E$$

$$area = work = E_{k_f} - E_{k_i}$$

$$area = work = \frac{1}{2}m\left(v_f\right)^2 - \frac{1}{2}m\left(v_i\right)^2$$

$$\frac{1}{2}m\left(v_f\right)^2 = work + \frac{1}{2}m\left(v_i\right)^2$$

$$v_f = \sqrt{\frac{2\left(work + \frac{1}{2}m\left(v_i\right)^2\right)}{m}} = \sqrt{\frac{2\left(1120J + \frac{1}{2}\cdot 14kg\cdot (4m/s)^2\right)}{14kg}} = \underline{13.27m/s}$$

102. How long will it take a 2,625 W motor to lift a 1545 kg piano to a window 20 m above the ground (assume the motor is 100% efficient)? **(3 marks)**

ANSWER: (3 marks)

$$p = \frac{W}{t} = \frac{Fd}{t} = \frac{mgd}{t}$$

$$t = \frac{m\cdot g\cdot d}{P} = \frac{1545kg\cdot 9.8m/s^2\cdot 20m}{2,625W} = \underline{\underline{115.36s}}$$

103. How high does a 70 % efficient 4 hp motor lift 6 kg in 80 seconds? (1 hp = 746 watts) **(3 marks)**

ANSWER: (3 marks)

$$P_{input} = 4hp \times \frac{746W}{1hp} = 2,984W$$

$$Efficiency = \frac{P_{output}}{P_{input}} \times 100\%$$

$$P_{output} = \frac{Efficiency}{100\%}\cdot P_{input} = \frac{70\%}{100\%}\cdot 2,984W = 2,088.8W$$

$$P = \frac{W}{t} = \frac{F\cdot d}{t}$$

$$d = \frac{P\cdot t}{F} = \frac{P\cdot t}{m\cdot g} = \frac{2,088.8W\cdot 80s}{6kg\cdot 9.8m/s^2} = \underline{\underline{2,841.9m}}$$

104. How efficient is a 1 hp motor if it can lift a 60 kg object 66 m in 80 seconds? (1 hp = 746 watts) **(3 marks)**

ANSWER: (3 marks)

$$P_{output} = \frac{W}{t} = \frac{F \cdot d}{t} = \frac{m \cdot g \cdot d}{t} = \frac{60kg \cdot 9.8m/s^2 \cdot 66m}{80s} = 485.1W$$

$$P_{input} = 1hp \times \frac{746W}{1hp} = 746W$$

$$Efficiency = \frac{P_{output}}{P_{input}} \times 100\% = \frac{485.1W}{746W} \times 100\% = \underline{\underline{65.03\%}}$$

105. What hp is a motor rated at if it is 60% efficient and can lift a 25 kg object 90 m in 30 seconds? (1 hp = 746 watts) **(3 marks)**

ANSWER: (3 marks)

$$P_{output} = \frac{W}{t} = \frac{F \cdot d}{t} = \frac{m \cdot g \cdot d}{t} = \frac{25kg \cdot 9.8m/s^2 \cdot 90m}{30s} = 735W$$

$$Efficiency = \frac{P_{output}}{P_{input}} \times 100\%$$

$$P_{input} = \frac{P_{output}}{Efficiency} \times 100\% = \frac{735W}{60\%} \times 100\% = 1,225W \times \frac{1hp}{746W} = \underline{\underline{1.64hp}}$$

106.

A pump is to lift 14 kg of water per minute through a height of 22 m. What output rating (watts) should the pump motor have?(assume the pump is 100% efficient) **(3 marks)**

ANSWER: (3 marks)

$$P = \frac{W}{t} = \frac{F \cdot d}{t} = \frac{m \cdot g \cdot d}{t} = \frac{14kg \cdot 9.8m/s^2 \cdot 22m}{60s} = \underline{\underline{50.31W}}$$

107. In the high jump, the kinetic energy of an athlete is transformed into gravitational potential energy with the aid of a pole. With what minimum speed must the athlete leave the ground in order to clear the bar at a height of 3.1 m and cross the bar with a speed of 1.3 m/s? **(3 marks)**

ANSWER: (3 marks)

$$E_{T_{initial}} = E_{T_{final}}$$

$$E_k + E_p = E'_k + E'_p$$

$$\frac{1}{2}mv^2 + mgh = \frac{1}{2}m\left(v'\right)^2 + mgh'$$

$$v = \sqrt{2\left(\frac{1}{2}\left(v'\right)^2 + gh'\right)} = \sqrt{2\left(\frac{1}{2}(1.3m/s)^2 + 9.8m/s^2 \cdot 3.1m\right)} = \underline{\underline{7.9m/s}}$$

108. A student is standing on top of a 28 m cliff and throws their physics book up at 6 m/s. What is velocity of the book, when it is 5 m **below** the edge of the cliff. **(3 marks)**

ANSWER: (3 marks)

$$E_{T_{initial}} = E_{T_{final}}$$

$$E_k + E_p = E_k' + E_p'$$

$$\frac{1}{2}\cancel{m}v^2 + \cancel{m}gh = \frac{1}{2}\cancel{m}\left(v'\right)^2 + \cancel{m}gh'$$

$$\frac{1}{2}\left(v'\right)^2 = \frac{1}{2}v^2 + gh - gh'$$

$$v' = \sqrt{2\left(\frac{1}{2}v^2 + gh - gh'\right)} = \sqrt{2\left(\frac{1}{2}(6m/s)^2 + 9.8m/s^2 \cdot 28m - 9.8m/s^2(28m - 5m)\right)} = \underline{\underline{11.58m/s}}$$

109. How efficient is a 4.8 kW heater if it heats a 30 kg block of Aluminum (c= 878 J/kg/K) from –46 °C to 85 °C in 17 minutes? **(3 marks)**

ANSWER: (3 marks)

$$E_h = mc\Delta T = 30kg \cdot 878J/kg/°C \cdot \left(85°C - (-46°C)\right) = 3,450,540J$$

$$P_{output} = \frac{W}{t} = \frac{\Delta E}{t} = \frac{E_h}{t} = \frac{3,450,540J}{17\min \times \frac{60s}{\min}} = 3,382.88W$$

$$P_{input} = 4.8kW \times \frac{1000W}{1kW} = 4,800W$$

$$Efficiency = \frac{P_{output}}{P_{input}} \times 100\% = \frac{3,382.88W}{4,800W} \times 100\% = \underline{\underline{70.48\%}}$$

110. If you remove 41,700J from a 7 block of Zinc (c=388 J/kg/°C) that is at 24 °C, what is it's final temperature? **(3 marks)**

ANSWER: (3 marks)

$$E_h = mc\Delta T = mc(T_f - T_i)$$

$$T_f = \frac{-E_h}{mc} + T_i = \frac{-41,700J}{7kg \cdot 388J/kg/°C} + 24°C = \underline{\underline{8.65°C}}$$

111. How many litres (1 L = 1 kg, but you already knew that) of 98 °C water is needed to be added to a 200 L bath at 12 °C in order to bring it up to 44 °C. (c= 4200 J/kg/K) **(3 marks)**

ANSWER: (3 marks)

$$m_{bath} ¢\Delta T = -m_{add} ¢\Delta T$$

$$m_{add} = -\frac{m_{bath}\Delta T}{\Delta T} = -\frac{200L \cdot (44°C - 12°C)}{(44°C - 98°C)} = \underline{118.52L}$$

112. Water flows over a section of Niagara Falls at the rate of 3.9×10^6 kg/s and falls 72 m. What is the power wasted by the waterfall (in GigaWatts)? **(3 marks)**

ANSWER: (3 marks)

$$P = \frac{W}{t} = \frac{Fd}{t} = \frac{mgd}{t} = \frac{3.9\times 10^6 kg \cdot 9.8N/kg \cdot 72m}{1s} = \underline{2,751,840,000W} \quad \text{OR} \quad \underline{2.8GW}$$

113. A 4,900 kg freight car is rolling along a track at –20 m/s [West]. Calculate the time needed for a force of 350 N [East]to make the car go 13 m/s [East] ? **(3 marks)**

ANSWER: (3 marks)

$$F\Delta t = \Delta p = m\Delta v = m\left(v_f - v_i\right)$$

$$\Delta t = \frac{m \cdot \left(v_f - v_i\right)}{F} = \frac{4,900kg \cdot (13m/s - -20m/s)}{350N} = \underline{462s}$$

114. A 4,700 kg freight car is rolling along a track at 20 m/s [East]. Calculate the time needed for a force of –910 N [West]to make the car go 15 m/s [West] ? **(3 marks)**

ANSWER: (3 marks)

$$F\Delta t = \Delta p = m\Delta v = m\left(v_f - v_i\right)$$

$$\Delta t = \frac{m \cdot \left(v_f - v_i\right)}{F} = \frac{4,700kg \cdot (-15m/s - 20m/s)}{-910N} = \underline{180.77s}$$

115. A 3,300 kg freight car is rolling along a track at 13 m/s [East]. A force is applied for 16s. Calculate the force and direction of the force to make the freight car go 18 m/s [West] ? **(3 marks)**

ANSWER: (3 marks)

$$F\Delta t = \Delta p = m\Delta v = m\left(v_f - v_i\right)$$

$$F = \frac{m \cdot \left(v_f - v_i\right)}{\Delta t} = \frac{3,300kg \cdot (-18m/s - 13m/s)}{16s} = \underline{6,393.75N[West]}$$

116. A golf ball at rest of mass 0.34 kg acquires a speed of 132 m/s when hit with a force of 1,540 N. How long was the club in contact with the ball? **(3 marks)**

ANSWER: (3 marks)

$$F\Delta t = \Delta p = m\Delta v = m \cdot \left(v_f - v_i\right)$$

$$\Delta t = \frac{m\left(v_f - v_i\right)}{F} = \frac{0.34kg \cdot (132m/s - 0m/s)}{1,540N} = \underline{\underline{0.029s}}$$

117. A golf ball at rest, acquires a speed of 51 m/s when hit with a force of 3,620 N for 0.008s. What is the mass of the golf ball? **(3 marks)**

ANSWER: (3 marks)

$$F\Delta t = \Delta p = m\Delta v = m\left(v_f - v_i\right)$$

$$m = \frac{F\Delta t}{\left(v_f - v_i\right)} = \frac{3,620N \cdot 0.008s}{(51m/s - 0m/s)} = \underline{\underline{0.57kg}}$$

118. A golfer hits a 0.75 kg golf ball with a force of 3,760 N. The club is in contact with the ball for 0.006 s. How fast does the golf ball leave the tee? **(3 marks)**

ANSWER: (3 marks)

$$F\Delta t = \Delta p = m\Delta v = m\left(v_f - v_i\right)$$

$$v_f = \frac{F\Delta t}{m} + v_i = \frac{3,760N \cdot 0.006s}{0.75kg} + 0m/s = \underline{\underline{30.08m/s}}$$

119. A 14 kg object is moving with a velocity of 14 m/s to the right when it collides with a 16 kg ball heading left at 12 m/s. After the collision, the 14 kg object is moving left at a velocity of 17 m/s. What is the velocity of the 16 kg object after the collision (state direction, left or right)? **(3 marks)**

ANSWER: (3 marks)

$$p_i = p_f$$

$$p_1 + p_2 = p_1' + p_2'$$

$$m_1 v_1 + m_2 v_2 = m_1 v_1' + m_2 v_2'$$

$$v_2' = \frac{m_1 v_1 + m_2 v_2 - m_1 v_1'}{m_2} = \frac{14kg \cdot 14m/s + 16kg \cdot -12m/s - 14kg \cdot -17m/s}{16kg} = \underline{\underline{15.13m/s\ [right]}}$$

120. A red ball is moving with a velocity of 9 m/s to the right when it collides (but does not stick together) with a 19 kg blue ball heading left at 24 m/s. After the collision, the red ball is moving left at a velocity of 13 m/s. The velocity of the 19 kg blue ball after the collision is 22 m/s to the right. What is the mass of the red ball? **(3 marks)**

ANSWER: (3 marks)

$p_i = p_f$

$p_1 + p_2 = p_1' + p_2'$

$m_1 v_1 + m_2 v_2 = m_1 v_1' + m_2 v_2'$

$m_1(9m/s) + 19kg \cdot -24m/s = m_1(-13m/s) + 19kg \cdot 22m/s$

$9m_1 + 13m_1 = 19kg \cdot 24m/s + 19kg \cdot 22m/s$

$(9m/s + 13m/s)m_1 = 19kg \cdot 24m/s + 19kg \cdot 22m/s$

$$m_1 = \frac{19kg \cdot 24m/s + 19kg \cdot 22m/s}{(9m/s + 13m/s)} = \underline{\underline{39.73kg}}$$

121. A 15 kg object is moving with a velocity of 21 m/s to the right when it collides with a 19 kg ball heading left at 5 m/s. After the collision the two masses stick together. What velocity do the two objects move off together? **(3 marks)**

ANSWER: (3 marks)

$p_i = p_f$

$p_1 + p_2 = p_1' + p_2'$

$m_1 v_1 + m_2 v_2 = (m_1 + m_2) \cdot v'$

$$v' = \frac{m_1 v_1 + m_2 v_2}{m_1 + m_2} = \frac{15kg \cdot 21m/s + 19kg \cdot -5m/s}{15kg + 19kg} = \underline{\underline{6.47m/s\ [right]}}$$

122. A rocket motor, capable of generating a 155 N•s impulse, is attached to a frictionless 15 kg cart that is already moving at a constant velocity of 3 m/s. The rocket motor is ignited. What will the velocity of the cart be immediately after the rocket motor burns out? **(3 marks)**

ANSWER: (3 marks)

$impulse = \Delta p = m\Delta v = m\left(v_f - v_i\right)$

$$v_f = \frac{impulse}{m} + v_i = \frac{155N \cdot s}{15kg} + 3m/s = \underline{\underline{13.33m/s}}$$

123. A rocket scientist wants their 17 kg rocket to obtain a final velocity of 630 m/s. How large of an impulse is needed to achieve the required final velocity? **(3 marks)**

ANSWER: (3 marks)

$$impulse = \Delta p = m\Delta v = m\left(v_f - v_i\right) = 17kg \cdot (630m/s - 0m/s) = \underline{\underline{10,710N \cdot s}}$$

124. If a 7.8 kg gun recoils at a speed of 6.9 m/s, then how heavy must the bullet be if it leaves the gun at a rate of 980 m/s? **(3 marks)**

ANSWER: (3 marks)

$$p_i = p_f$$

$$0 + 0 = p'_{gun} + p'_{bullet}$$

$$-p'_{bullet} = p'_{gun}$$

$$-m_{gun} \cdot v'_{gun} = m_{bullet} \cdot v'_{bullet}$$

$$m_{bullet} = \frac{-m_{gun} \cdot v'_{gun}}{v'_{bullet}} = \frac{-7.8kg \cdot -6.9m/s}{980m/s} = \underline{\underline{0.055kg}}$$

125. A person fires a gun and a 0.07 kg bullet leaves the barrel of the gun at a rate of 920 m/s. If the gun recoils at a rate of 3.6 m/s, then how heavy is the gun? **(3 marks)**

ANSWER: (3 marks)

$$p_i = p_f$$

$$0 + 0 = p'_{gun} + p'_{bullet}$$

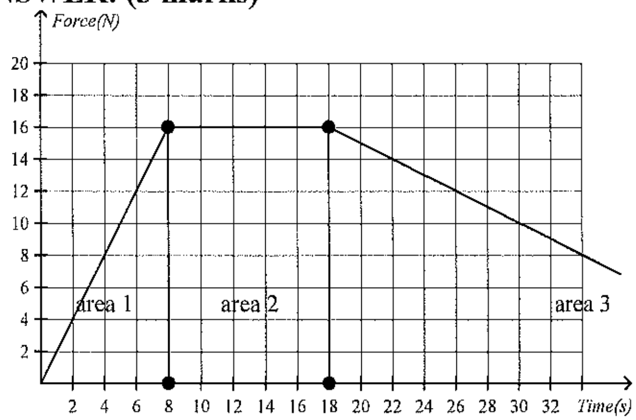
$$p'_{gun} = -p'_{bullet}$$

$$m_{gun} \cdot v'_{gun} = -m_{bullet} \cdot v'_{bullet}$$

$$m_{gun} = \frac{-m_{bullet} \cdot v'_{bullet}}{v'_{gun}} = \frac{-0.07kg \cdot 920m/s}{-3.6m/s} = \underline{\underline{17.89kg}}$$

126. A 19 kg model vehicle travelling at 13 m/s [to the right] experiences a push [to the left] for a certain period of time as shown on the graph. What is the resulting velocity and indicate the direction of motion? **(3 marks)**

ANSWER: (3 marks)



$$area_1 = \frac{1}{2} \cdot b \cdot h = \frac{1}{2} \cdot 8s \cdot 2N = 64N \cdot s$$

$$area_2 = b \cdot h = (18s - 8s) \cdot 16N = 160N \cdot s$$

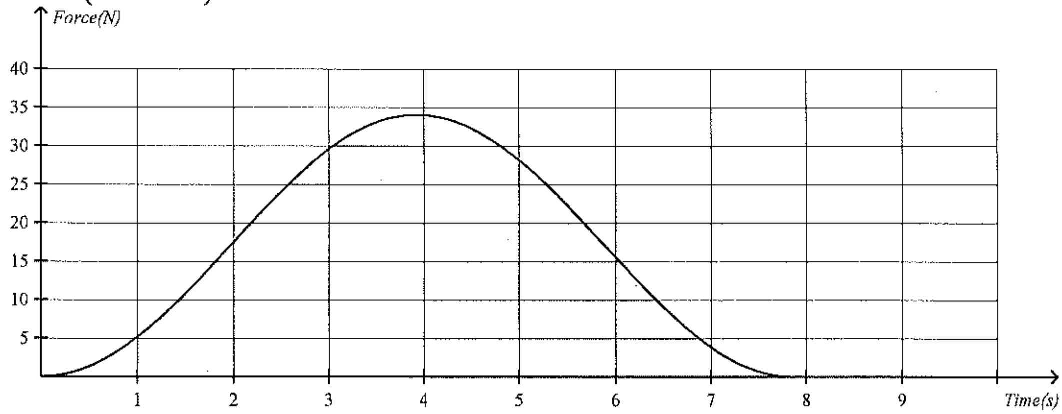
$$area_3 = \frac{1}{2} \cdot b \cdot h = \frac{1}{2} \cdot (50s - 18s) \cdot 16N = 256N \cdot s$$

$$area_{total} = area_1 + area_2 + area_3 = 64N \cdot s + 160N \cdot s + 256N \cdot s = \underline{480N \cdot s}$$

$area = -impulse = \Delta p = m\Delta v = m\left(v_f - v_i\right)$ (because the impulse is to the left, it is a negative value)

$$v_f = \frac{-impulse}{m} + v_i = \frac{-480N \cdot s}{19kg} + 13m/s = \underline{\underline{-12.26m/s}}$$

127. A 9 kg model vehicle travelling at 2 m/s [to the right] experiences a push [to the left] for a certain period of time as shown on the graph. What is the resulting velocity and indicate the direction of motion? **(3 marks)**



ANSWER: (3 marks)

area under the curve = $\underline{127.02N\cdot s}$

$area = -impulse = \Delta p = m\Delta v = m\left(v_f - v_i\right)$ (because the impulse is to the left, it is a negative value)

$$v_f = \frac{-impulse}{m} + v_i = \frac{-127.02N\cdot s}{9kg} + 2m/s = \underline{-12.11m/s\ [left]}$$

128. A 62 kg astronaut is floating at a distance of 291 m from the International Space Station. If they throw their 7 kg tool in the opposite direction from the station at a velocity of 1 m/s, how long in seconds or minutes will it take the astronaut to reach the station? **(3 marks)**

ANSWER: (3 marks)

First we need to determine the velocity of the astronaut after they have thrown the tool.

$$p_i = p_f$$

$$0 + 0 = p'_{astronaut} + p'_{tool}$$

$$p'_{astronaut} = -p'_{tool}$$

$$m_{astronaut}\cdot v'_{astronaut} = -m_{tool}\cdot v'_{tool}$$

$$v'_{astronaut} = \frac{-m_{tool}\cdot v'_{tool}}{m_{astronaut}} = \frac{-7kg\cdot -1m/s}{62kg} = \underline{\underline{0.11m/s}}$$

Now find the time it takes the astronaut to cover the required distance.

$$d = v\cdot t$$

$$t = \frac{d}{v} = \frac{291m}{0.11m/s} = \underline{\underline{2,577.43s}} \quad \text{OR} \quad \underline{\underline{42.96\,\text{min}}} \quad \text{OR} \quad \underline{\underline{0.72h}}$$

129. Outside the International Space Station, a 79 kg astronaut holding a 8 kg tool (both initially at rest) throws the tool at 2 m/s relative to the space station. A 113 kg astronaut, initially at rest, catches the tool. What is the speed of separation of the two astronauts? **(3 marks)**

ANSWER: (3 marks)
First we need to determine the velocity of the astronaut after they have thrown the tool.

$$p_i = p_f$$

$$0 + 0 = p'_{astronaut} + p'_{tool}$$

$$p'_{astronaut} = -p'_{tool}$$

$$m_{astronaut} \cdot v'_{astronaut} = -m_{tool} \cdot v'_{tool}$$

$$v'_{astronaut} = \frac{-m_{tool} \cdot v'_{tool}}{m_{astronaut}} = \frac{-8kg \cdot -2m/s}{79kg} = 0.2m/s$$

Now find the collision (stick) velocity of the tool and second astronaut.

$$p_i = p_f$$

$$p_{tool} + p_{secondastronaut} = p'_{tool} + p'_{secondastronaut}$$

$$m_{tool} v_{tool} + 0 = (m_{tool} + m_{secondastronaut}) v'$$

$$v' = \frac{m_{tool} v_{tool}}{(m_{tool} + m_{secondastronaut})} = \frac{8kg \cdot 2m/s}{(8kg + 113kg)} = 0.13m/s$$

Finally, add the two velocities together to get the separation velocity.

$$v_{separation} = v_{firstastronaut} + v_{secondastronaut} = 0.2m/s + 0.13m/s = \underline{\underline{0.33m/s}}$$

130. There are two canoes on the lake. One canoe has two people in it that weighs 1,000 N and the other canoe has three people and it weighs 1,945 N. One person pushed the other canoe with a force of 460 N for 0.6 s. What is the speed of separation of the two canoes? **(3 marks)**

ANSWER: (3 marks)

$$W_1 = m_1 g \quad m_1 = \frac{W_1}{g} = \frac{1,000N}{9.8N/kg} = 102.04kg \qquad W_2 = m_2 g \quad m_2 = \frac{W_2}{g} = \frac{1,945N}{9.8N/kg} = 198.47kg$$

$$F\Delta t = m\Delta v$$

$$v_f - v_i = \frac{F\Delta t}{m_1} = \frac{460N \cdot 0.6s}{102.04} = 2.7m/s$$

$$v_f - v_i = \frac{F\Delta t}{m_2} = \frac{460N \cdot 0.6s}{198.47} = 1.39m/s$$

Finally, add the two velocities together to get the separation velocity.

$$v_{separation} = v_1 + v_2 = 2.7m/s + 1.39m/s = \underline{\underline{4.1m/s}}$$

131. A 75 kg person is riding on 14 kg cart at a velocity of 20 m/s. With what velocity does the person need to jump forward in order to stop the cart? **(3 marks)**

ANSWER: (3 marks)

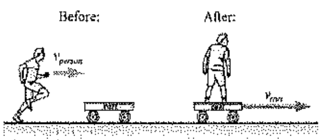
$$p_i = p_f$$

$$p_1 + p_2 = p_1' + p_2'$$

$$(m_1 + m_2)\cdot v = m_1 v_1' + m_2 v_2'$$

$$v' = \frac{(m_1 + m_2)\cdot v}{m_1} = \frac{(75kg + 14kg)\cdot 20m/s}{75kg} = \underline{\underline{23.73m/s}}$$

132. A 89 kg person runs along at a velocity of 8.5 m/s and jumps onto a 30 kg stationary cart. How fast does the person and cart move afterwards? **(3 marks)**



ANSWER: (3 marks)

$$p_i = p_f$$

$$m_p v_p' + m_c v_c' = \left(m_p + m_c\right) v'$$

$$v' = \frac{m_p v_p}{\left(m_p + m_c\right)} = \frac{89kg \cdot 8.5m/s}{\left(89kg + 30kg\right)} = \underline{\underline{6.36m/s}}$$

133. $p_i = p_f$

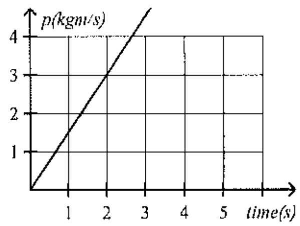
$$0 + 0 = p'_{boy_1 + cart} + p'_{boy_2 + cart}$$

$$p'_{boy_2 + cart} = -p'_{boy_1 + cart}$$

$$m_{boy_2 + cart}\cdot v'_{cart} = -m_{boy_1 + cart}\cdot v'_{cart}$$

$$v'_{cart_2} = \frac{-m_{boy_1 + cart}\cdot v'_{cart_1}}{m_{boy_2 + cart}} = \frac{-(63kg + 12kg)\cdot -6m/s}{(71kg + 12kg)} = \underline{\underline{5.42m/s}}$$

134. This graph depicts the motion of a box being pushed across the floor for 8s.



What is the force acting on the box? **(2 marks)**

ANSWER: (2 marks)

$F\Delta T = \Delta p$

$$F = \frac{\Delta p}{\Delta T} = slope = \frac{12kg \cdot m/s - 0kg \cdot m/s}{8s - 0s} = \frac{12kg \cdot m/s}{8s} = \underline{\underline{1.5N}}$$

135. A rocket engine consumes 860 kg of fuel per minute. If the exhaust speed of the ejected fuel is 5.8 km/s, what is the thrust of the rocket? **(3 marks)**

ANSWER: (3 marks)

$F\Delta t = m\Delta v$

$$F = \frac{m\Delta v}{\Delta t} = \frac{860kg \cdot (5.8km/s \cdot 1000m/km)}{60s} = \underline{\underline{83,133.33N}}$$

136. Two blocks with masses 3.2 kg and 9.4 kg are placed on a horizontal frictionless surface. A light spring is placed in a horizontal position between the blocks. The blocks are pushed together, compressing the spring, and then released from rest. After contact with the spring ends, the 9.4 kg mass has a speed of 8 m/s. How much potential energy was stored in the spring when the blocks were released?

ANSWER: (3 marks)

$$p_1 + p_2 = p_1' + p_2'$$

$$0 + 0 = m_1 \cdot v_1' + m_2 \cdot v_2'$$

$$m_1 \cdot v_1' = m_2 \cdot v_2'$$

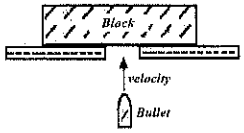
$$v_1' = \frac{m_2 \cdot v_2'}{m_1} = \frac{3.2kg \cdot 23.5m/s}{3.2kg} = 23.5m/s$$

$$E_{K_1} = \tfrac{1}{2} m_1 \left(v_1\right)^2 = \tfrac{1}{2} 3.2kg \cdot (23.5m/s)^2 = 883.60J$$

$$E_{K_2} = \tfrac{1}{2} m_2 \left(v_2\right)^2 = \tfrac{1}{2} 9.4kg \cdot (8m/s)^2 = 300.80J$$

$$E_{P_{Total}} = E_{K_1} + E_{K_2} = 883.60J + 300.80J = \underline{\underline{1,184.40J}}$$

137. A 0.20 kg bullet moving 540 m/s strikes and sticks in the 9.1 kg block initially at rest, as shown below. What maximum height will the block (with the bullet embedded) rise above its initial position? **(3 marks)**



ANSWER: (3 marks)

$p_{initial} = p_{final}$

$$m_1 v_1 + m_2 \cancel{v}_2 = \left(m_1 + m_2\right)v'$$

$$v' = \frac{m_1 v_1}{\left(m_1 + m_2\right)} = \frac{0.20kg \cdot 540m/s}{\left(0.20kg + 9.1kg\right)} = 11.61m/s$$

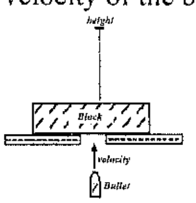
$$E_{T_{initial}} = E_{T_{final}}$$

$$\cancel{E}_P + E_K = E_P' + \cancel{E}_K'$$

$$\tfrac{1}{2}\cancel{m}v^2 = \cancel{m}gh$$

$$h = \frac{v^2}{2g} = \frac{(11.61m/s)^2}{2 \cdot 9.8N/kg} = \underline{\underline{6.88m}}$$

138. A 0.40 kg bullet moving at a certain velocity strikes and sticks in the 2.6 kg block initially at rest, as shown below. If the block (with the bullet embedded) rises 23.2 m above it's original position, what was the initial velocity of the bullet? **(3 marks)**



ANSWER: (3 marks)

$$E_{T_{initial}} = E_{T_{final}}$$

$$\cancel{E}_P + E_K = E_P' + \cancel{E}_K'$$

$$\tfrac{1}{2}\cancel{m}v^2 = \cancel{m}gh \qquad v = \sqrt{2gh} = \sqrt{2 \cdot 9.8N/kg \cdot 23.2m} = 21.32m/s$$

$p_{initial} = p_{final}$

$$m_1 v_1 + m_2 \cancel{v}_2 = \left(m_1 + m_2\right)v'$$

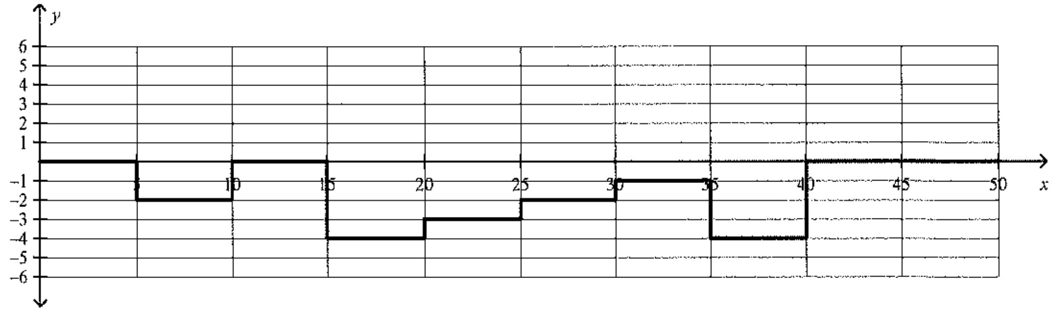
$$v_1 = \frac{\left(m_1 + m_2\right)v'}{m_1} = \frac{\left(0.40kg + 2.6kg\right)21.32m/s}{0.40kg} = \underline{\underline{159.93m/s}}$$

139. 1

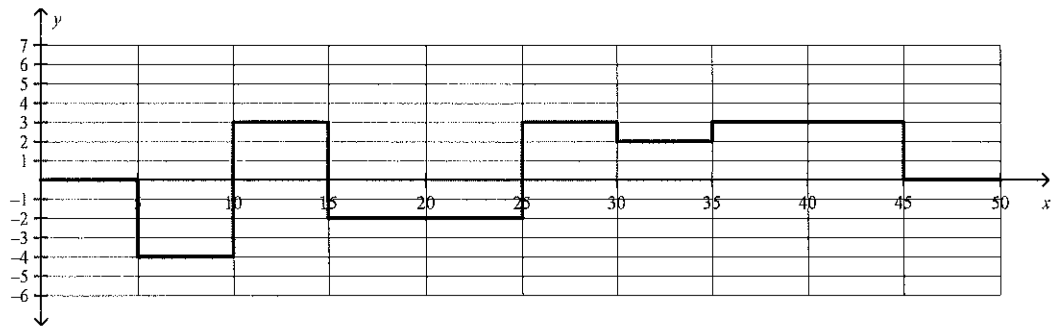
140. 1

141. Sketch the result of superimposing the following two waves. **(2 marks)**
ANSWER: (2 marks)

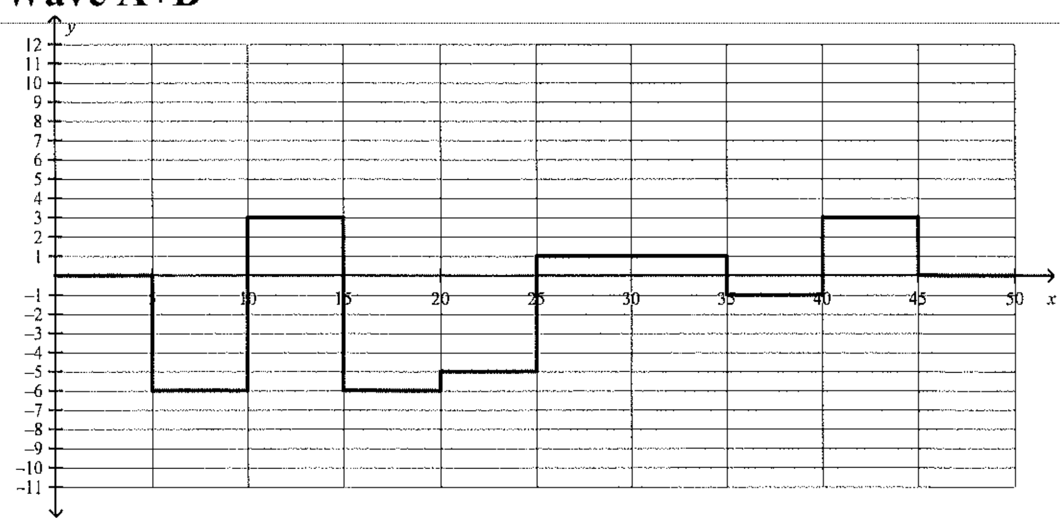
Wave A



Wave B

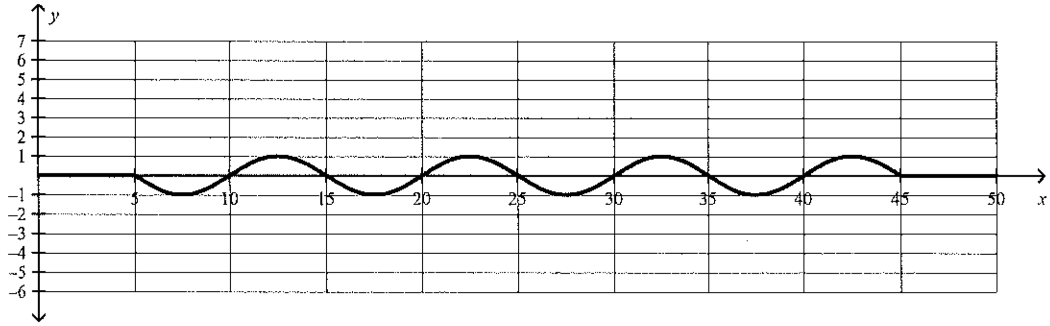


Wave A+B

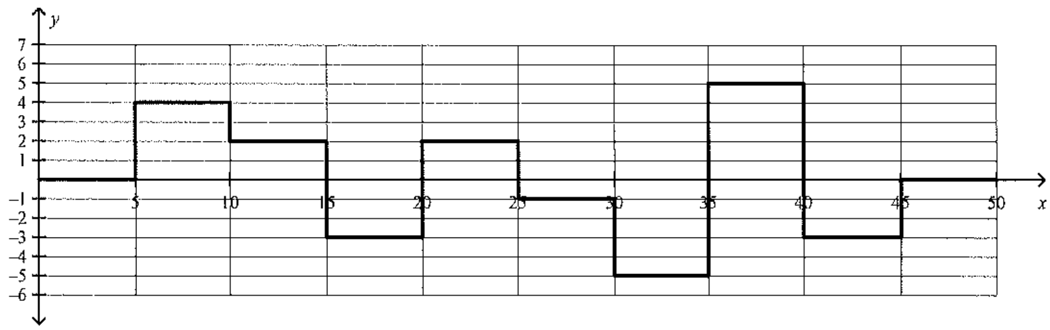


142. Sketch the result of superimposing the following two waves. **(2 marks)**
ANSWER: (2 marks)

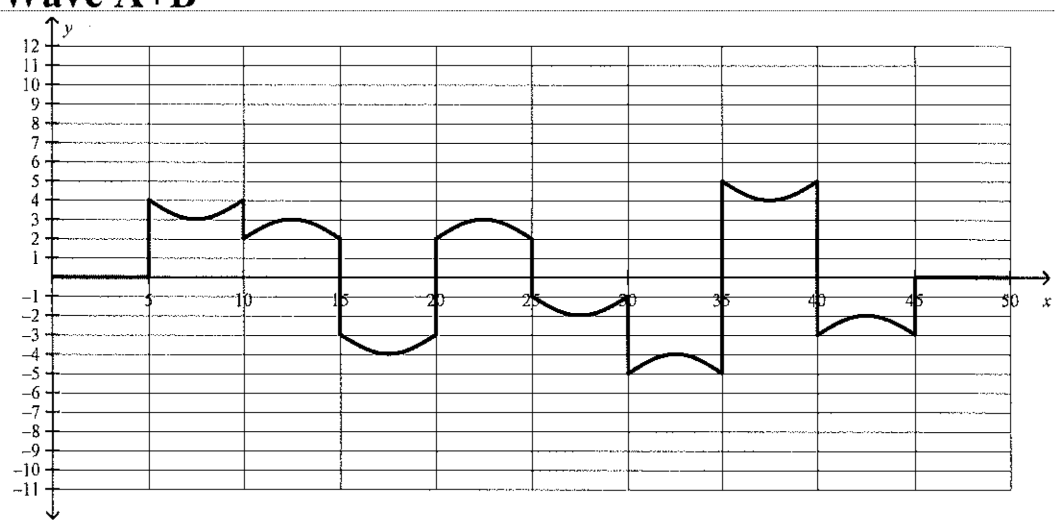
Wave A



Wave B

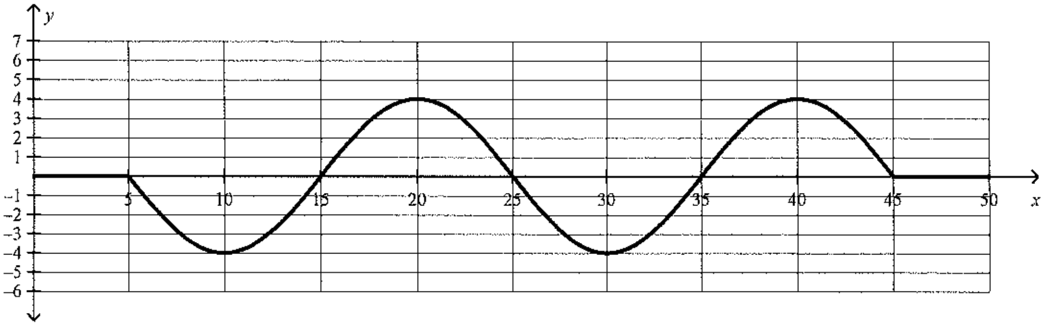


Wave A+B

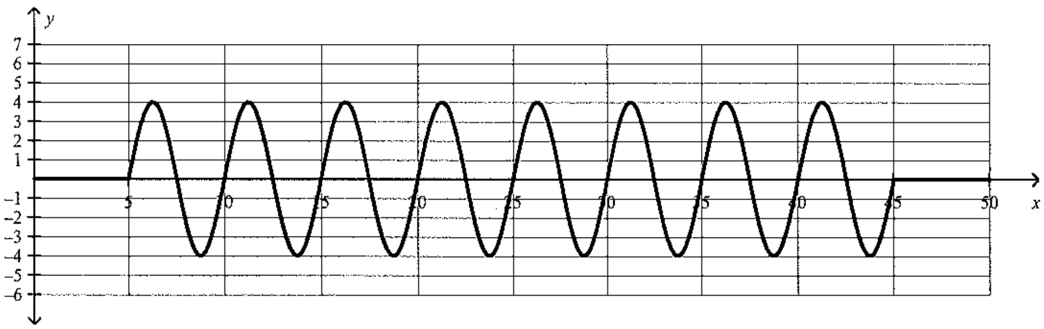


143. Sketch the result of superimposing the following two waves. **(2 marks)**
ANSWER: (2 marks)

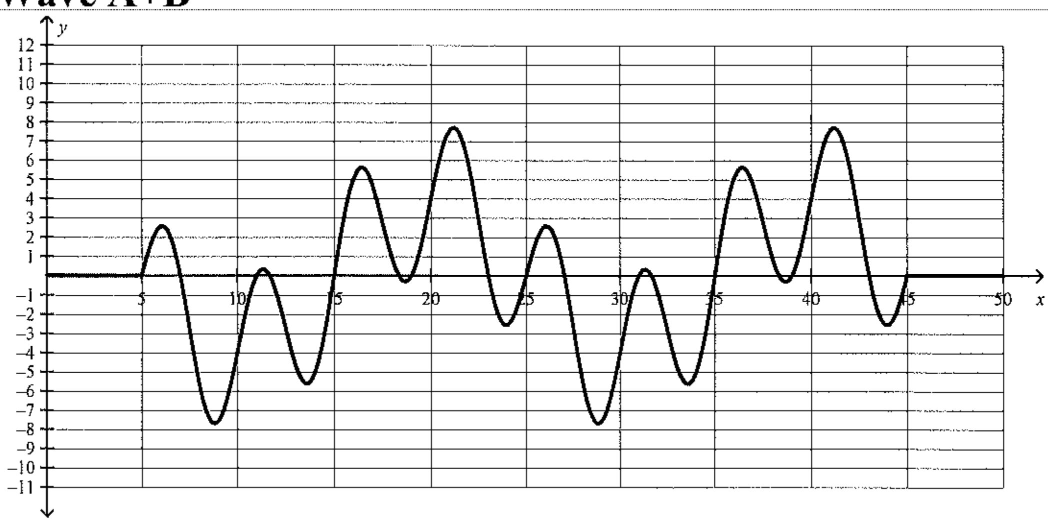
Wave A



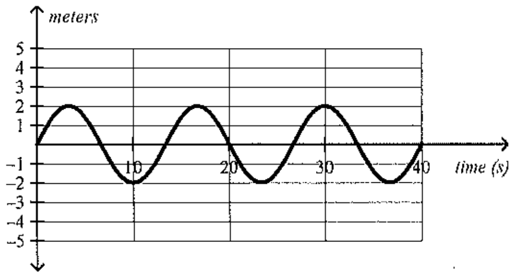
Wave B



Wave A+B



144. The wave shown below travels 180 m in 40 seconds. Answer the questions below.



ANSWER: (6 marks)

a) What is the amplitude of the wave? **(1 mark)**

$$amplitude = \underline{2m}$$

b) What is the wavelength of the wave? **(1 mark)**

$$v = f\lambda \quad \lambda = \frac{v}{f} = \frac{4.5m/s}{0.075Hz} = \underline{60m}$$

c) What is the velocity of the wave? **(1 mark)**

$$v = \frac{d}{t} = \frac{180m}{40s} = \underline{4.5m/s}$$

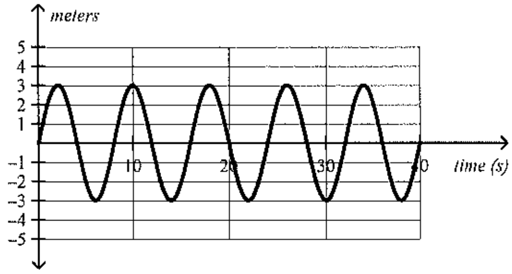
d) What is the frequency of the wave? **(1 mark)**

$$f = \frac{cycles}{\text{sec}} = \frac{3\ cycles}{40\ \text{sec}} = \underline{0.075Hz}$$

e) What is the period of the wave? **(1 mark)**

$$T = \frac{1}{f} = \frac{1}{0.075Hz} = \underline{13.33s}$$

145. The wave shown below travels 90 m in 40 seconds. Answer the questions below.



ANSWER: (6 marks)

a) What is the amplitude of the wave? **(1 mark)**

amplitude = $\underline{3m}$

b) What is the velocity of the wave? **(1 mark)**

$$v = \frac{d}{t} = \frac{90m}{40s} = \underline{2.25m/s}$$

c) What is the frequency of the wave? **(1 mark)**

$$f = \frac{cycles}{\text{sec}} = \frac{5\ cycles}{40\ \text{sec}} = \underline{0.13Hz}$$

d) What is the period of the wave? **(1 mark)**

$$T = \frac{1}{f} = \frac{1}{0.13Hz} = \underline{8s}$$

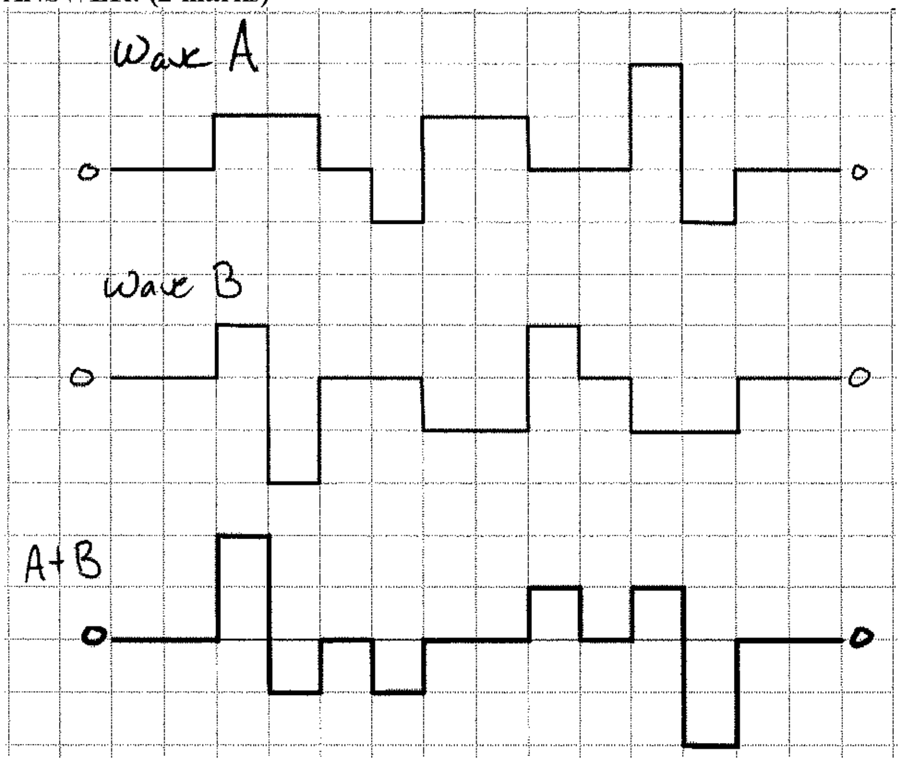
e)What is the wavelength of the wave? **(1 mark)**

$$v = f\lambda \quad \lambda = \frac{v}{f} = \frac{2.25m/s}{0.13Hz} = \underline{18m}$$

f) How many nodes and antinodes are there? **(1 mark)**

$\underline{nodes = 11}$ $\underline{antinodes = 10}$

146. Sketch the result of superimposing the following two waves. **(2 marks)**
ANSWER: (2 marks)



147. A standing wave in a clothesline has 8 nodes and 7 antinodes. The clothesline is 6 m long and is vibrating at 0.8 vibrations per second. What is the speed of the wave? **(3 marks)**

ANSWER: (3 marks)
The number of waves is:

$$\#waves = \frac{nodes - 1}{2} = \frac{8 - 1}{2} = 3.5$$

The wave length of each wave is:

$$\lambda = \frac{length}{\#waves} = \frac{6m}{3.5} = 1.71m$$

The velocity of the wave is:

$$v = f \cdot \lambda = 0.8Hz \cdot 1.71m = \underline{\underline{1.37m/s}}$$

148. The speed of an ocean wave on the coast is 38 m/s; the wavelength is 28 m. What is the frequency with which the wave hits the beach? **(2 marks)**

ANSWER: (2 marks)
$v = f \cdot \lambda$

$$f = \frac{v}{\lambda} = \frac{38m/s}{28m} = \underline{\underline{1.36Hz}}$$

149. A sound wave with a frequency of 340 Hz has a wavelength of 0.7 m. What is the velocity of the sound wave? **(2 marks)**

ANSWER: (2 marks)
$v = f \cdot \lambda = 340Hz \cdot 0.7m = \underline{\underline{238m/s}}$

150. What is the speed of light in quartz (n=1.54)? **(2 marks)**

ANSWER:

$$n_s = \frac{c}{v_s}$$

$$v_s = \frac{c}{n_s} = \frac{3\times 10^8 m/s}{1.54} = \underline{\underline{1.95\times 10^8 m/s}}$$

151. If light is travelling at 42% the speed of light in a translucent material, what is the index of refraction of the material **(2 marks)**
ANSWER:

$$n = \frac{c}{v} = \frac{3\times 10^8 m/s}{42\% \cdot 3\times 10^8 m/s} = \underline{\underline{2.38}}$$

152. How far would a beam of light travel in a block of water (n=1.33) in 9.9×10^{-7} seconds? **(3 marks)**
ANSWER:

$$n = \frac{c}{v}$$

$$v = \frac{c}{n} = \frac{3\times 10^8 m/s}{1.33} = 2.26\times 10^8 m/s$$

$$d = v \cdot t = 2.26\times 10^8 m/s \cdot 9.9\times 10^{-7} s = \underline{\underline{223.31m}}$$

153. What is the index of refraction for a piece material that light can travel 5.5 m in 2.7×10^{-8} seconds? **(3 marks)**
ANSWER:

$$d = v \cdot t \qquad v = \frac{d}{t} = \frac{5.5m}{2.7\times 10^{-7} s} = 2.04\times 10^8 m/s$$

$$n = \frac{c}{v} = \frac{3\times 10^8 m/s}{2.04\times 10^8 m/s} = \underline{\underline{1.47}}$$

154. A ray of light passes from quartz (n=1.54) into water (n=1.33) at an angle of incidence of 10°. Find the angle of refraction. **(3 marks)**

ANSWER:

$$n_i \cdot \sin\theta_i = n_r \cdot \sin\theta_r$$

$$\sin^{-1}\theta_r = \frac{n_i \cdot \sin\theta_i}{n_r} = \frac{1.54 \cdot \sin 10°}{1.33} = \underline{\underline{11.6°}}$$

155. A ray of light passes from water (n=1.33) into diamond (n=2.42) and refracts at an angle of 10°. Find the angle of incidence. **(3 marks)**

ANSWER:

$n_i \cdot \sin\theta_i = n_r \cdot \sin\theta_r$

$$\sin^{-1}\theta_i = \frac{n_r \cdot \sin\theta_r}{n_i} = \frac{2.42 \cdot \sin 10^\circ}{1.33} = \underline{\underline{18.42^\circ}}$$

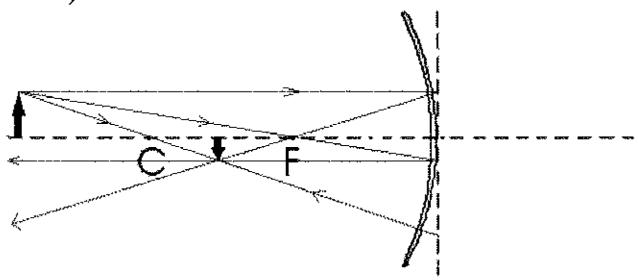
156. What is the critical angle of a light ray when passing from diamond (n=2.42) into flint glass (n=1.61) ? **(3 marks)**

ANSWER:

$n_i \cdot \sin\theta_C = n_r \cdot \sin 90^\circ$

$$\sin^{-1}\theta_C = \frac{n_r \cdot \sin 90^\circ}{n_i} = \frac{1.61}{2.42} = \underline{\underline{41.7^\circ}}$$

157. There is a concave mirror that has a center with a radius of 90 cm.
The 7 cm object is located 135 cm from the mirror.
ANSWER: Determine each of the following:
a) Draw the ray diagram carefully (use arrows on your lines to indicate direction of light ray). Draw your lines to the veritical dotted line behind the mirror before reflecting. Clearly draw the image produced. **(1 mark)**



b) Find the distance to the image. **(2 marks)**

$$f = \frac{C}{2} = \frac{90cm}{2} = 45cm$$

$$\frac{1}{d_o} + \frac{1}{d_i} = \frac{1}{f} \qquad \frac{1}{d_i} = \frac{1}{f} - \frac{1}{d_o}$$

$$d_i = \frac{1}{\left(f\right)^{-1} - \left(d_o\right)^{-1}} = \frac{1}{(45cm)^{-1} - (135cm)^{-1}} = \underline{\underline{67.5cm}} \quad \text{(same side as object)}$$

c) Find the image height **(1 mark)**

$$\frac{h_i}{h_o} = \frac{-d_i}{d_o}$$

$$h_i = -\frac{h_o \cdot \left(d_i\right)}{d_o} = -\frac{7cm \cdot (67.5cm)}{135cm} = \underline{\underline{-3.5cm}} \quad \text{(inverted)}$$

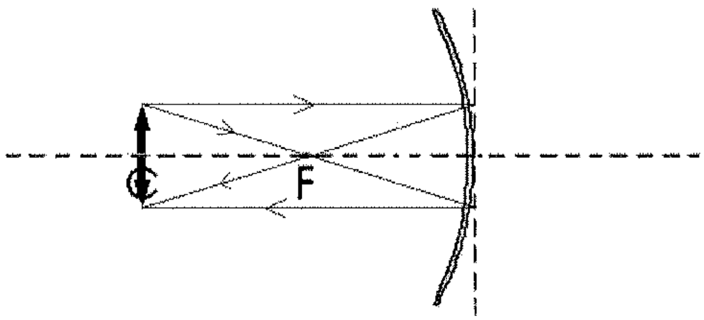
d) Determine if the image is real or imaginary/virtual. **(1/2 mark)**

REAL

e) Find the magnification factor. **(1/2 mark)**

$$m = \frac{h_i}{h_o} = \frac{-3.5cm}{7cm} = \underline{\underline{-0.5}} \qquad \text{OR} \qquad m = \frac{-d_i}{d_o} = \frac{-67.5cm}{135cm} = \underline{\underline{-0.5}}$$

158. There is a concave mirror that has a center with a radius of 66 cm.
The 10 cm object is located 66 cm from the mirror.
ANSWER: Determine each of the following:
a) Draw the ray diagram carefully (use arrows on your lines to indicate direction of light ray). Draw your lines to the veritical dotted line behind the mirror before reflecting. Clearly draw the image produced. **(1 mark)**



b) Find the distance to the image. **(2 marks)**

$$f=\frac{C}{2}=\frac{66cm}{2}=33cm$$

$$\frac{1}{d_o}+\frac{1}{d_i}=\frac{1}{f} \qquad \frac{1}{d_i}=\frac{1}{f}-\frac{1}{d_o}$$

$$d_i=\frac{1}{\left(f\right)^{-1}-\left(d_o\right)^{-1}}=\frac{1}{(33cm)^{-1}-(66cm)^{-1}}=\underline{\underline{66cm}} \text{ (same side as object)}$$

c) Find the image height **(1 mark)**

$$\frac{h_i}{h_o}=\frac{-d_i}{d_o}$$

$$h_i=-\frac{h_o\cdot\left(d_i\right)}{d_o}=-\frac{10cm\cdot(66cm)}{66cm}=\underline{\underline{-10cm}} \text{ (inverted)}$$

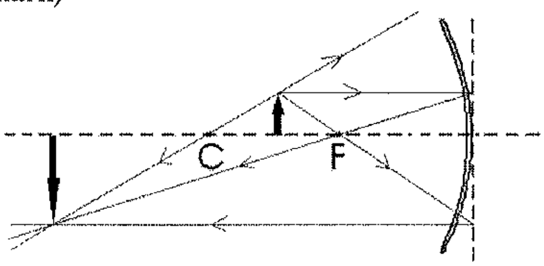
d) Determine if the image is real or imaginary/virtual. **(1/2 mark)**

REAL

e) Find the magnification factor. **(1/2 mark)**

$$m=\frac{h_i}{h_o}=\frac{-10cm}{10cm}=\underline{\underline{-1}} \qquad \text{OR} \qquad m=\frac{-d_i}{d_o}=\frac{-66cm}{66cm}=\underline{\underline{-1}}$$

159. There is a concave mirror that has a center with a radius of 120 cm.
The 16 cm object is located 69 cm from the mirror.
ANSWER: Determine each of the following:
a) Draw the ray diagram carefully (use arrows on your lines to indicate direction of light ray). Draw your lines to the veritical dotted line behind the mirror before reflecting. Clearly draw the image produced. **(1 mark)**



b) Find the distance to the image. **(2 marks)**

$$f = \frac{C}{2} = \frac{120cm}{2} = 60cm$$

$$\frac{1}{d_o} + \frac{1}{d_i} = \frac{1}{f} \qquad \frac{1}{d_i} = \frac{1}{f} - \frac{1}{d_o}$$

$$d_i = \frac{1}{\left(f\right)^{-1} - \left(d_o\right)^{-1}} = \frac{1}{(60cm)^{-1} - (69cm)^{-1}} = \underline{\underline{460cm}} \quad \text{(same side as object)}$$

c) Find the image height **(1 mark)**

$$\frac{h_i}{h_o} = \frac{-d_i}{d_o}$$

$$h_i = -\frac{h_o \cdot \left(d_i\right)}{d_o} = -\frac{16cm \cdot (460cm)}{69cm} = \underline{\underline{-106.67cm}} \quad \text{(inverted)}$$

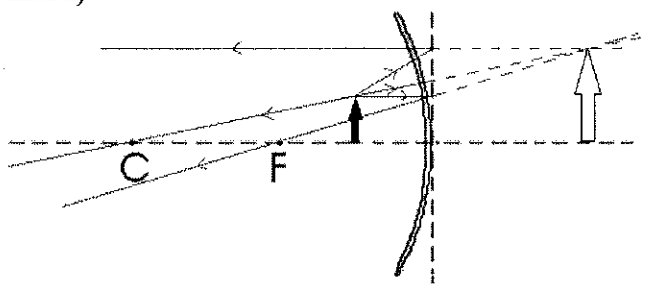
d) Determine if the image is real or imaginary/virtual. **(1/2 mark)**

REAL

e) Find the magnification factor. **(1/2 mark)**

$$m = \frac{h_i}{h_o} = \frac{-106.67cm}{16cm} = \underline{\underline{-6.667}} \qquad \text{OR} \qquad m = \frac{-d_i}{d_o} = \frac{-460cm}{69cm} = \underline{\underline{-6.667}}$$

160. There is a concave mirror that has a center with a radius of 102 cm.
The 9 cm object is located 30 cm from the mirror.
ANSWER: Determine each of the following:
a) Draw the ray diagram carefully (use arrows on your lines to indicate direction of light ray). Draw your lines to the veritical dotted line behind the mirror before reflecting. Clearly draw the image produced. **(1 mark)**



b) Find the distance to the image. **(2 marks)**

$$f = \frac{C}{2} = \frac{102cm}{2} = 51cm$$

$$\frac{1}{d_o} + \frac{1}{d_i} = \frac{1}{f} \qquad \frac{1}{d_i} = \frac{1}{f} - \frac{1}{d_o}$$

$$d_i = \frac{1}{\left(f\right)^{-1} - \left(d_o\right)^{-1}} = \frac{1}{(51cm)^{-1} - (30cm)^{-1}} = \underline{\underline{-72.86cm}} \text{ (behind mirror)}$$

c) Find the image height **(1 mark)**

$$\frac{h_i}{h_o} = \frac{-d_i}{d_o}$$

$$h_i = -\frac{h_o \cdot \left(d_i\right)}{d_o} = -\frac{9cm \cdot (-72.86cm)}{30cm} = \underline{\underline{21.86cm}} \text{ (upright)}$$

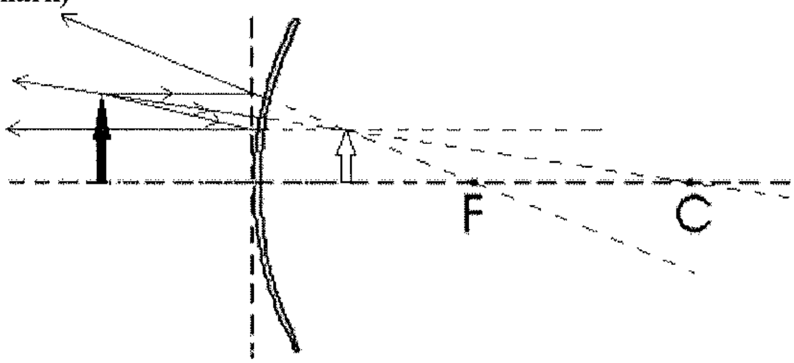
d) Determine if the image is real or imaginary/virtual. **(1/2 mark)**

Imaginary/Virtual

e) Find the magnification factor. **(1/2 mark)**

$$m = \frac{h_i}{h_o} = \frac{21.86cm}{9cm} = \underline{\underline{2.429}} \qquad \text{OR} \qquad m = \frac{-d_i}{d_o} = \frac{--72.86cm}{30cm} = \underline{\underline{2.429}}$$

161. There is a convex mirror that has a center with a radius of 108 cm.
The 14 cm object is located 53 cm from the mirror.
ANSWER: Determine each of the following:
a) Draw the ray diagram carefully (use arrows on your lines to indicate direction of light ray). Draw your lines to the veritical dotted line infront of the mirror before reflecting. Clearly draw the image produced. **(1 mark)**



b) Find the distance to the image. **(2 marks)**

$$f = \frac{C}{2} = \frac{108cm}{2} = -54cm$$

$$\frac{1}{d_o} + \frac{1}{d_i} = \frac{1}{f} \qquad \frac{1}{d_i} = \frac{1}{f} - \frac{1}{d_o}$$

$$d_i = \frac{1}{\left(f\right)^{-1} - \left(d_o\right)^{-1}} = \frac{1}{(-54cm)^{-1} - (53cm)^{-1}} = \underline{\underline{-26.75cm}} \text{ (behind mirror)}$$

c) Find the image height **(1 mark)**

$$\frac{h_i}{h_o} = \frac{-d_i}{d_o}$$

$$h_i = -\frac{h_o \cdot \left(d_i\right)}{d_o} = -\frac{14cm \cdot (-26.75cm)}{53cm} = \underline{\underline{7.07cm}} \text{ (upright)}$$

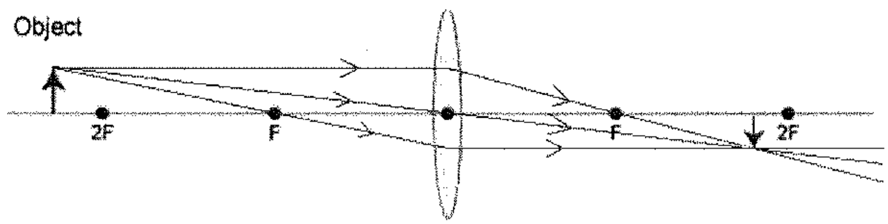
d) Determine if the image is real or imaginary/virtual. **(1/2 mark)**

Imaginary/Virtual

e) Find the magnification factor. **(1/2 mark)**

$$m = \frac{h_i}{h_o} = \frac{7.07cm}{14cm} = \underline{\underline{0.505}} \qquad \text{OR} \qquad m = \frac{-d_i}{d_o} = \frac{--26.75cm}{53cm} = \underline{\underline{0.505}}$$

162. There is a convex lens that has a focal point of 50 cm.
The 19 cm object is located 114 cm from the lens.
ANSWER: Determine each of the following:
a) Draw the ray diagram carefully (use arrows on your lines to indicate direction of light ray). Draw your lines to the middle of the lens before refracting. Clearly draw the image produced. **(1 mark)**



b) Find the distance to the image. **(2 marks)**

$$\frac{1}{d_o}+\frac{1}{d_i}=\frac{1}{f} \qquad \frac{1}{d_i}=\frac{1}{f}-\frac{1}{d_o}$$

$$d_i=\frac{1}{\left(f\right)^{-1}-\left(d_o\right)^{-1}}=\frac{1}{(50cm)^{-1}-(114cm)^{-1}}=\underline{\underline{89.06cm}}$$ (opposite side to object)

c) Find the image height **(1 mark)**

$$\frac{h_i}{h_o}=\frac{-d_i}{d_o}$$

$$h_i=-\frac{h_o\cdot\left(d_i\right)}{d_o}=-\frac{19cm\cdot(89.06cm)}{114cm}=\underline{\underline{-14.84cm}}$$ (inverted)

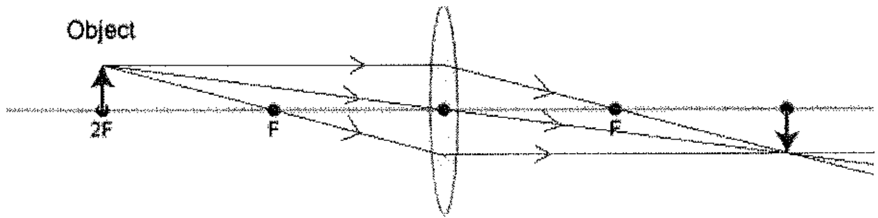
d) Determine if the image is real or imaginary/virtual. **(1/2 mark)**

Real

e) Find the magnification factor. **(1/2 mark)**

$$m=\frac{h_i}{h_o}=\frac{-14.84cm}{19cm}=\underline{\underline{-0.781}} \qquad \text{OR} \qquad m=\frac{-d_i}{d_o}=\frac{-89.06cm}{114cm}=\underline{\underline{-0.781}}$$

163. There is a convex lens that has a focal point of 15 cm.
The 19 cm object is located 30 cm from the lens.
ANSWER: Determine each of the following:
a) Draw the ray diagram carefully (use arrows on your lines to indicate direction of light ray). Draw your lines to the middle of the lens before refracting. Clearly draw the image produced. **(1 mark)**



b) Find the distance to the image. **(2 marks)**

$$\frac{1}{d_o} + \frac{1}{d_i} = \frac{1}{f} \qquad \frac{1}{d_i} = \frac{1}{f} - \frac{1}{d_o}$$

$$d_i = \frac{1}{\left(f\right)^{-1} - \left(d_o\right)^{-1}} = \frac{1}{(15cm)^{-1} - (30cm)^{-1}} = \underline{\underline{30cm}} \text{ (opposite side to object)}$$

c) Find the image height **(1 mark)**

$$\frac{h_i}{h_o} = \frac{-d_i}{d_o}$$

$$h_i = -\frac{h_o \cdot \left(d_i\right)}{d_o} = -\frac{19cm \cdot (30cm)}{30cm} = \underline{\underline{-19cm}} \text{ (inverted)}$$

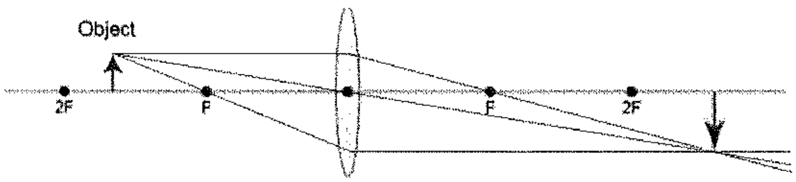
d) Determine if the image is real or imaginary/virtual. **(1/2 mark)**

Real

e) Find the magnification factor. **(1/2 mark)**

$$m = \frac{h_i}{h_o} = \frac{-19cm}{19cm} = \underline{\underline{-1}} \qquad \text{OR} \qquad m = \frac{-d_i}{d_o} = \frac{-30cm}{30cm} = \underline{\underline{-1}}$$

164. There is a convex lens that has a focal point of 25 cm.
The 5 cm object is located 38 cm from the lens.
ANSWER: Determine each of the following:
a) Draw the ray diagram carefully (use arrows on your lines to indicate direction of light ray). Draw your lines to the middle of the lens before refracting. Clearly draw the image produced. **(1 mark)**



b) Find the distance to the image. **(2 marks)**

$$\frac{1}{d_o} + \frac{1}{d_i} = \frac{1}{f} \qquad \frac{1}{d_i} = \frac{1}{f} - \frac{1}{d_o}$$

$$d_i = \frac{1}{\left(f\right)^{-1} - \left(d_o\right)^{-1}} = \frac{1}{(25cm)^{-1} - (38cm)^{-1}} = \underline{\underline{73.08cm}}$$ (opposite side to object)

c) Find the image height **(1 mark)**

$$\frac{h_i}{h_o} = \frac{-d_i}{d_o}$$

$$h_i = -\frac{h_o \cdot \left(d_i\right)}{d_o} = -\frac{5cm \cdot (73.08cm)}{38cm} = \underline{\underline{-9.62cm}}$$ (inverted)

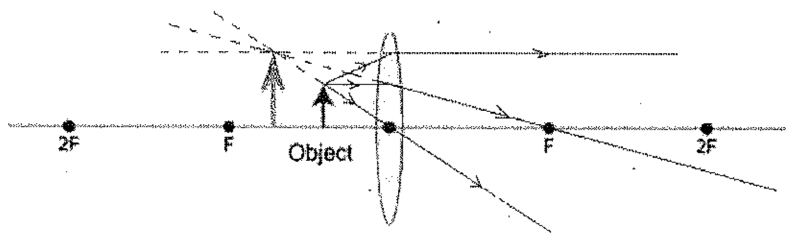
d) Determine if the image is real or imaginary/virtual. **(1/2 mark)**

Real

e) Find the magnification factor. **(1/2 mark)**

$$m = \frac{h_i}{h_o} = \frac{-9.62cm}{5cm} = \underline{\underline{-1.923}} \qquad \text{OR} \qquad m = \frac{-d_i}{d_o} = \frac{-73.08cm}{38cm} = \underline{\underline{-1.923}}$$

165. There is a convex lens that has a focal point of 35 cm.
The 10 cm object is located 30 cm from the lens.
ANSWER: Determine each of the following:
a) Draw the ray diagram carefully (use arrows on your lines to indicate direction of light ray). Draw your lines to the middle of the lens before refracting. Clearly draw the image produced. **(1 mark)**



b) Find the distance to the image. **(2 marks)**

$$\frac{1}{d_o}+\frac{1}{d_i}=\frac{1}{f} \qquad \frac{1}{d_i}=\frac{1}{f}-\frac{1}{d_o}$$

$$d_i=\frac{1}{\left(f\right)^{-1}-\left(d_o\right)^{-1}}=\frac{1}{(35cm)^{-1}-(30cm)^{-1}}=\underline{\underline{-210cm}} \quad \text{(same side as object)}$$

c) Find the image height **(1 mark)**

$$\frac{h_i}{h_o}=\frac{-d_i}{d_o}$$

$$h_i=-\frac{h_o\cdot\left(d_i\right)}{d_o}=-\frac{10cm\cdot(-210cm)}{30cm}=\underline{\underline{70cm}} \quad \text{(up right)}$$

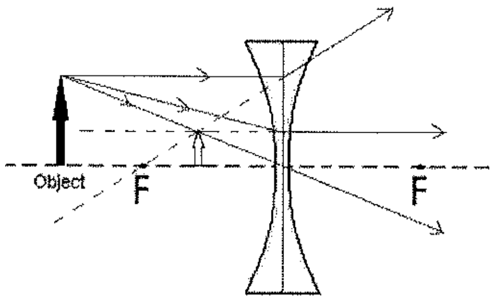
d) Determine if the image is real or imaginary/virtual. **(1/2 mark)**

Imaginary/ Virtual

e) Find the magnification factor. **(1/2 mark)**

$$m=\frac{h_i}{h_o}=\frac{70cm}{10cm}=\underline{\underline{7}} \qquad \text{OR} \qquad m=\frac{-d_i}{d_o}=\frac{--210cm}{30cm}=\underline{\underline{7}}$$

166. There is a concave lens that has a focal point of –26 cm.
The 8 cm object is located 35 cm from the lens.
ANSWER: Determine each of the following:
a) Draw the ray diagram carefully (use arrows on your lines to indicate direction of light ray). Draw your lines to the middle of the lens before refracting. Clearly draw the image produced. **(1 mark)**



b) Find the distance to the image. **(2 marks)**

$$\frac{1}{d_o}+\frac{1}{d_i}=\frac{1}{f} \qquad \frac{1}{d_i}=\frac{1}{f}-\frac{1}{d_o}$$

$$d_i=\frac{1}{\left(f\right)^{-1}-\left(d_o\right)^{-1}}=\frac{1}{(-26cm)^{-1}-(35cm)^{-1}}=\underline{\underline{-14.92cm}}$$ (same side as object)

c) Find the image height **(1 mark)**

$$\frac{h_i}{h_o}=\frac{-d_i}{d_o}$$

$$h_i=-\frac{h_o\cdot\left(d_i\right)}{d_o}=-\frac{8cm\cdot(-14.92cm)}{35cm}=\underline{\underline{3.41cm}}$$ (up right)

d) Determine if the image is real or imaginary/virtual. **(1/2 mark)**

Imaginary/ Virtual

e) Find the magnification factor. **(1/2 mark)**

$$m=\frac{h_i}{h_o}=\frac{3.41cm}{8cm}=\underline{\underline{0.426}} \qquad \text{OR} \qquad m=\frac{-d_i}{d_o}=\frac{--14.92cm}{35cm}=\underline{\underline{0.426}}$$

167. A 17 cm object that is 11 cm from a convex mirror, has an upright image of 10.2 cm. Determine the focal length of the mirror **(2 marks)**
ANSWER:

$$\frac{h_i}{h_o} = \frac{-d_i}{d_o}$$

$$d_i = -\frac{h_i \cdot d_o}{h_o} = -\frac{10.2cm \cdot 11cm}{17cm} = \underline{\underline{-6.6cm}}$$

$$\frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i}$$

$$f = \frac{1}{\left(d_o\right)^{-1} + \left(d_i\right)^{-1}} = \frac{1}{(11cm)^{-1} + (-6.6cm)^{-1}} = \underline{\underline{-16.5cm}} \quad \text{(- convex mirror)}$$

168. A 10 cm object is 14 cm from a concave mirror with a focal point of 3 cm. Determine how far the image is from the mirror. **(2 marks)**
ANSWER:

$$\frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i}$$

$$\frac{1}{d_i} = \frac{1}{f} - \frac{1}{d_o}$$

$$d_i = \frac{1}{\left(f\right)^{-1} - \left(d_o\right)^{-1}} = \frac{1}{(3cm)^{-1} - (14cm)^{-1}} = \underline{\underline{3.82cm}}$$

169. A 13 cm object is 9 cm from a convex mirror with a focal point of 23 cm. Determine how far the image is from the mirror. **(2 marks)**
ANSWER:

$$\frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i} \quad \text{(- focal point because convex mirror)}$$

$$\frac{1}{d_i} = \frac{1}{f} - \frac{1}{d_o}$$

$$d_i = \frac{1}{\left(f\right)^{-1} - \left(d_o\right)^{-1}} = \frac{1}{(-23cm)^{-1} - (9cm)^{-1}} = \underline{\underline{-6.47cm}}$$

170. A 10 cm object is 6 cm from a diverging lens with a focal point of 29 cm. Determine how far the image is from the lens. **(2 marks)**

ANSWER:

$$\frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i}$$ (- focal point because of diverging lens)

$$\frac{1}{d_i} = \frac{1}{f} - \frac{1}{d_o}$$

$$d_i = \frac{1}{\left(f\right)^{-1} - \left(d_o\right)^{-1}} = \frac{1}{(-29cm)^{-1} - (6cm)^{-1}} = \underline{\underline{-4.97cm}}$$

171. A 19 cm object is 14 cm from a converging lens with a focal point of 17 cm. Determine how far the image is from the lens. **(2 marks)**

ANSWER:

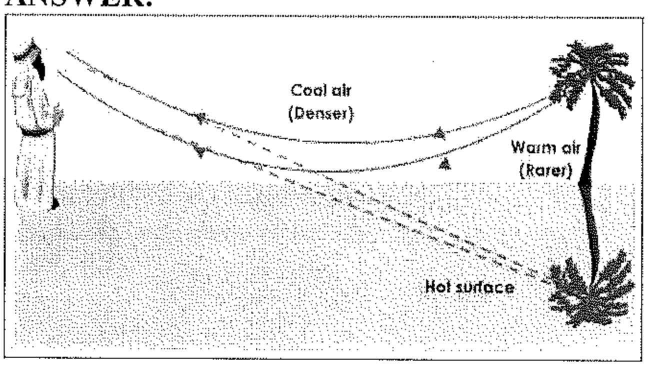
$$\frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i}$$

$$\frac{1}{d_i} = \frac{1}{f} - \frac{1}{d_o}$$

$$d_i = \frac{1}{\left(f\right)^{-1} - \left(d_o\right)^{-1}} = \frac{1}{(17cm)^{-1} - (14cm)^{-1}} = \underline{\underline{-79.33cm}}$$

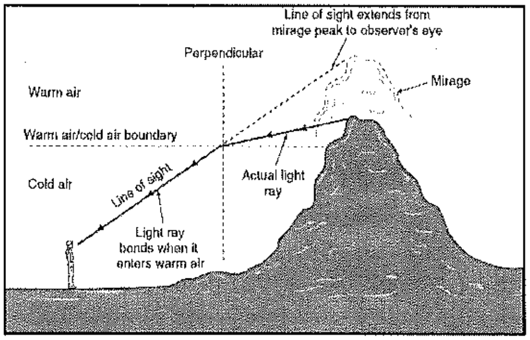
172. Using a GOOD diagram, draw a desert mirage. Label main parts and explain what is happening (in one or two sentences) **(1 mark)**

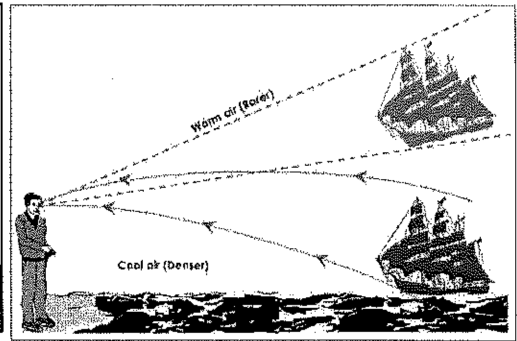
ANSWER:



173. Using a GOOD diagram, draw an arctic mirage. Label main parts and explain what is happening (in one or two sentences) **(1 mark)**

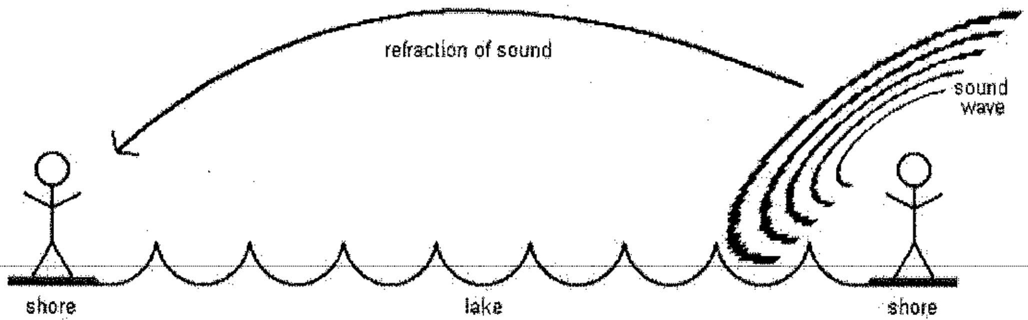
ANSWER:





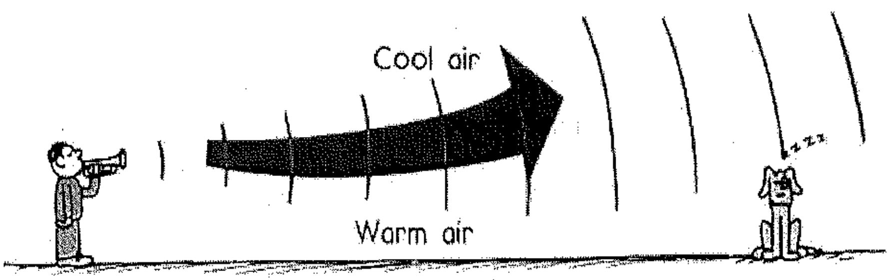
174. Using a GOOD diagram, show why you can hear people across a lake better than if you were across a field. Label main parts and explain what is happening (in one or two sentences) **(1 mark)**

ANSWER:



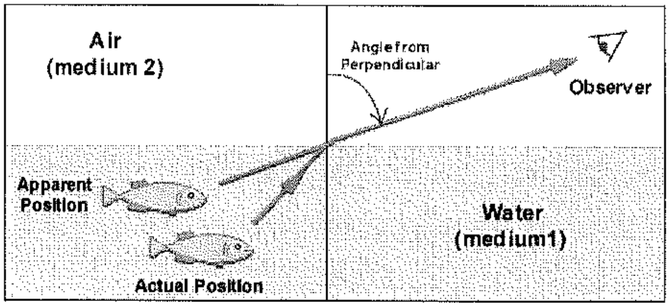
175. Using a GOOD diagram, show why it is harder to hear people in a desert then in a field . Label main parts and explain what is happening (in one or two sentences) **(1 mark)**

ANSWER:



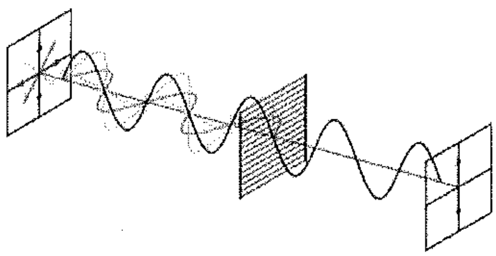
176. Using a GOOD diagram to show how light rays from a fish in the river looks to someone at the edge. Label main parts and explain what is happening (in one or two sentences) **(1 mark)**

ANSWER:



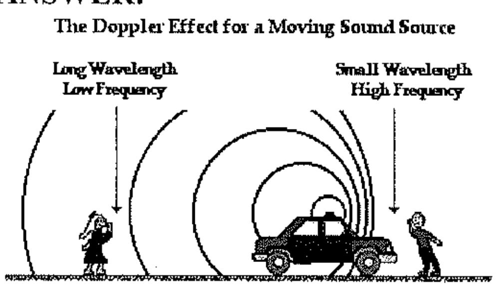
177. Explain how a light polarizer works using a GOOD diagram. Label main parts and explain what is happening (in one or two sentences) **(1 mark)**

ANSWER:



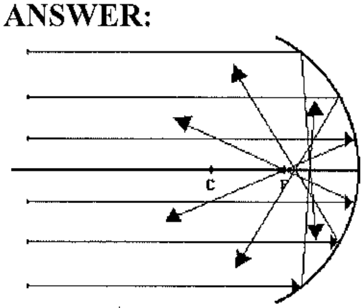
178. Explain how the doppler shift works using a GOOD diagram. Label main parts and explain what is happening (in one or two sentences) **(1 mark)**

ANSWER:

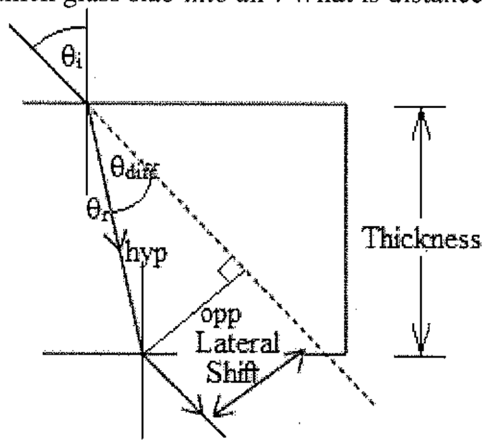


179. Explain what spherical abberation is using a GOOD diagram. Label main parts and explain what is happening (in one or two sentences) **(1 mark)**

ANSWER:



180. A light ray enters a 8 cm thick glass slab (n=1.7) at an angle of 60° to the normal. Then the light ray exits the thick glass slab into air . What is distance of the lateral shift? **(3 marks)**



ANSWER: (3 marks)

$$n_i \sin\left(\theta_i\right) = n_r \sin\left(\theta_r\right)$$

$$\theta_r = \frac{n_i \sin\left(\theta_i\right)}{n_r} = \frac{1.0003 \cdot \sin(60°)}{1.7} = 30.64°$$

$$\cos\left(\theta_r\right) = \frac{\text{adj}}{\text{hyp}} \qquad hyp = \frac{\text{adj}}{\cos\left(\theta_r\right)} = \frac{8cm}{\cos(30.64°)} = 9.298cm$$

$$\sin\left(\theta_i - \theta_r\right) = \frac{opp}{hyp} \qquad \text{Distance} = \sin(60° - 30.64°) \cdot hyp = \sin(29.36°) \cdot 9.298cm = \underline{\underline{4.559cm}}$$

181. If an astronaut has aged 48 years going to a distant star then another 48 years coming home, then how much time has passed on Earth during the trip if he has been moving at 0.95 c? **(3 marks)**

ANSWER: (3 marks)

$$\gamma = \frac{1}{\sqrt{1 - \frac{v^2}{c^2}}} = \frac{1}{\sqrt{1 - \frac{(0.95c)^2}{c^2}}} = 3.2$$

$$t = \gamma \cdot t_0 = 3.2 \times 2 \times 48\,years = \underline{\underline{307.45\,years}}$$

182. Your parents take you on a space voyage on your 6th birthday. When you get back from your trip, your best friend, who has the same birthday, is 16 years-old. If your ship was travelling at 0.9 c, how old are you (answer to 1 decimal)? **(3 marks)**

ANSWER: (3 marks)

$$\gamma = \frac{1}{\sqrt{1-\frac{v^2}{c^2}}} = \frac{1}{\sqrt{1-\frac{(0.9c)^2}{c^2}}} = 2.29$$

$$t = \gamma \cdot t_0$$

$$t_0 = \frac{t}{\gamma} = \frac{10y}{2.29} = 4.4y + 6y = \underline{\underline{10.4 \text{ years-old}}}$$

183. The starship Millenium Falcon is moving through space at 0.95 c. If the Millenium Falcon is 14 m long to the people on the Millenium Falcon, how long would it appear to a stationary observer? **(3 marks)**

ANSWER: (3 marks)

$$\gamma = \frac{1}{\sqrt{1-\frac{v^2}{c^2}}} = \frac{1}{\sqrt{1-\frac{(0.95c)^2}{c^2}}} = 3.2$$

$$L = \frac{L_0}{\gamma} = \frac{14m}{3.2} = \underline{\underline{4.37m}}$$

184. The starship Soyuz is moving through space at 0.5 c. A person on Earth sees the ship fly by and notes that it is only 37 m long. How long is it when it is sitting in the space dock? **(3 marks)**

ANSWER: (3 marks)

$$\gamma = \frac{1}{\sqrt{1-\frac{v^2}{c^2}}} = \frac{1}{\sqrt{1-\frac{(0.5c)^2}{c^2}}} = 1.15$$

$$L = \frac{L_0}{\gamma}$$

$$L_0 = \gamma \cdot L = 1.15 \times 37m = \underline{\underline{42.72m}}$$

185. a. How much energy would you get by changing 9 kg of gasoline into pure energy? **(2 marks)**
ANSWER: (2 marks)

$$E = mc^2 = 9kg \cdot (3 \times 10^8 m/s)^2 = \underline{\underline{8.1e+017J}}$$

b. How many times greater is this binding energy than the gasoline's chemical energy (39 Megajoule/kg)? **(1 mark)**
ANSWER: (1 mark)

$$\frac{\text{Binding Energy}}{\text{Chemical Energy}} = \frac{8.1e+017J}{39 \times 10^6 J \times 9kg} = \underline{\underline{2,307,692,308}} = \underline{\underline{2.307692307692e+009}}=$$

186. What is the relativistic mass of a muon traveling at 0.9c? (mass = 1.8e–028 kg) **(3 marks)**

ANSWER: (3 marks)

$$\gamma = \frac{1}{\sqrt{1-\frac{v^2}{c^2}}} = \frac{1}{\sqrt{1-\frac{(0.9c)^2}{c^2}}} = 2.29$$

$$M = \gamma \cdot M_0$$

$$M = \gamma \cdot M_0 = 2.29 \times 1.8e - 028kg = \underline{\underline{4.13e - 028kg}}$$

187. Mr. Roome is lying down in a spaceship travelling at a rate of 0.99 c. According to the stationary Parkland students watching him travel past, he looks 0.7 m from head to toe. How tall is he actually? **(3 marks)**

ANSWER: (3 marks)

$$\gamma = \frac{1}{\sqrt{1-\frac{v^2}{c^2}}} = \frac{1}{\sqrt{1-\frac{(0.99c)^2}{c^2}}} = 7.09$$

$$L = \frac{L_0}{\gamma}$$

$$L_0 = \gamma \cdot L = 7.09 \times 0.7m = \underline{\underline{4.96m}}$$

188. If a clock on a spaceship travelling at 0.995c moves 2.6 hours according to a stationary, outside observer, much time has actually passed for someone standing inside the ship? **(3 marks)**

ANSWER: (3 marks)

$$\gamma = \frac{1}{\sqrt{1-\frac{v^2}{c^2}}} = \frac{1}{\sqrt{1-\frac{(0.995c)^2}{c^2}}} = 10.01$$

$$t = \gamma \cdot t_0$$

$$t_0 = \frac{t}{\gamma} = \frac{2.6h}{10.01} = \underline{\underline{0.26h}}$$

189. If a stationary observer watches a spaceship travelling 0.9 c at for 1.3 hours, how much time has passed for someone standing inside the spaceship? **(3 marks)**

ANSWER: (3 marks)

$$\gamma = \frac{1}{\sqrt{1-\frac{v^2}{c^2}}} = \frac{1}{\sqrt{1-\frac{(0.9c)^2}{c^2}}} = 2.29$$

$$t = \gamma \cdot t_0 = 2.29 \cdot 1.3h = \underline{\underline{2.982404540317h}}$$

190. An astronaut leaves Earth at 0.98c. From inside the spaceship, the astronaut sees a solar system that is 6.1 light years away (1 light year is how far light travels in one year, which is quite far you know). How long will it take them to make a return trip, according to Earthlings? (in years)? **(3 marks)**

ANSWER: (3 marks)

$$\gamma = \frac{1}{\sqrt{1-\frac{v^2}{c^2}}} = \frac{1}{\sqrt{1-\frac{(0.98c)^2}{c^2}}} = 5.03$$

$$L = \frac{L_0}{\gamma}$$

$$L_0 = \gamma \cdot L = 5.03 \cdot 6.1Ly = 30.65Ly$$

$d = v \cdot t$ (there and back, double the distance)

$$t = \frac{2\times d}{v} = \frac{2\times 30.65Ly}{0.98c} = \underline{\underline{62.56 years}}$$

191. A student moving in a spaceship at 0.4c, is writing a Physics 11 Special Relativity test. He uses the full 80 minutes to complete the test. A Parkland student is writing the same test on Earth and sees the other student travel past. The Parkland student complains to the teacher that the moving student received more time for the exam. How long (in minutes) does the Parkland student think the moving student was given to write the test? **(3 marks)**

ANSWER: (3 marks)

$$\gamma = \frac{1}{\sqrt{1-\frac{v^2}{c^2}}} = \frac{1}{\sqrt{1-\frac{(0.4c)^2}{c^2}}} = 1.09$$

$$t = \gamma \cdot t_0 = 1.09 \cdot 80\,\text{min} = \underline{\underline{87.29\,\text{min}}}$$

192. An astronaut who is 62 kg is travelling on a spaceship at a velocity of 0.5c is on a diet. After several months he has lost 13 kg. According to a stationary observer, how heavy is the (still moving) astronaut after the diet? **(3 marks)**

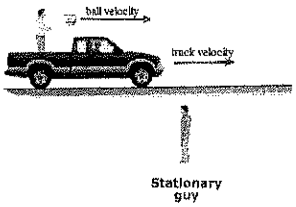
ANSWER: (3 marks)

$$\gamma = \frac{1}{\sqrt{1-\frac{v^2}{c^2}}} = \frac{1}{\sqrt{1-\frac{(0.5c)^2}{c^2}}} = 1.15$$

$$m_0 = \text{mass - diet} = 62kg - 13kg = 49kg$$

$$m = \gamma \cdot m_0 = 1.15 \cdot 49kg = \underline{\underline{56.58kg}}$$

193. A stationary man observes a truck moving past him at 0.8c. Another man is standing in the back of the truck and throws a baseball forward at 0.9c. How fast is the baseball moving with respect to the stationary man (answer to 4 decimal places)? **(3 marks)**



ANSWER: (3 marks)

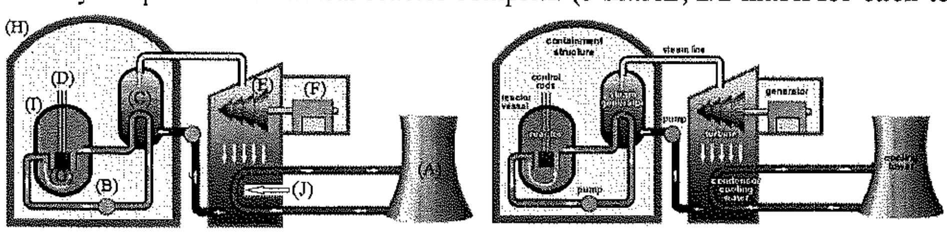
$$v = \frac{v_{ball}c + v_{truck}c}{1 + \frac{v_{ball}c \times v_{truck}c}{c^2}} = \frac{0.9c + 0.8c}{1 + \frac{0.9c \times 0.8c}{c^2}} = \underline{\underline{0.9884c}}$$

194. The spaceship Enterprise is moving at a velocity of 0.3c according to people on Earth. The spaceship Apollo is moving towards spaceship Enterprise at a velocity of 0.5c according to people on Earth. How fast does the captain of Enterprise see the spaceship Apollo approaching them (answer to 4 decimal places)? **(3 marks)**

ANSWER: (3 marks)

$$v = \frac{v_{left}c + v_{right}c}{1 + \frac{v_{left}c \times v_{right}c}{c^2}} = \frac{0.3c + 0.5c}{1 + \frac{0.3\not{c} \times 0.5\not{c}}{\not{c}^2}} = \underline{\underline{0.6957c}}$$

195. Identify the part of the nuclear reactor complex. **(5 marks, 1/2 mark for each term)**



Write the letters from the picture above beside the matching terms

ANSWERS: (5 marks, 1/2 mark for each term)

J	condensor cooling water	**G**	reactor core
B	pump	**F**	generator
I	reactor vessel	**A**	cooling tower
E	turbine	**H**	containment structure
D	control rods	**C**	Steam generator

196. What is the daughter product if the radioactive isotope Astatine-216 under goes alpha decay? **(2 marks)**

ANSWER: (2 marks)
$Astatine-216 \rightarrow Bismuth-212+{}_{2}^{4}He$

197. If the element Uranium-238 is produced after alpha decay, what was the parent isotope? **(2 marks)**

ANSWER: (2 marks)
$Plutonium-242 \rightarrow Uranium-238+{}_{2}^{4}He$

198. What is the daughter product if the radioactive isotope Berylium-9 under goes beta decay? **(2 marks)**

ANSWER: (2 marks)
$Berylium-9 \rightarrow Boron-9+{}_{-1}^{0}e$

199. If the element Potassium-38 is produced after beta decay, what was the parent isotope? **(2 marks)**

ANSWER: (2 marks)
$Argon-38 \rightarrow Potassium-38+{}_{-1}^{0}e$

200. List 2 advantages of a CANDU reactor over an american style reactor. **(2 marks)**
ANSWER: (2 marks)
1. Don't have to enrich U-235
2. The moderator is also the coolant, so if it leaks out, then the reaction stops

201. Describe how a control rod works. **(1 mark)**
ANSWER: (1 mark)
The control rods absorb or stop neutrons from continuing further reactions with other U-235 atoms.

202. What is a chain reaction when dealing with nuclear fission? **(1 mark)**
ANSWER: (1 mark)
When on nucleus of U-235 absorbs a neutron, it becomes unstable and splits apart, releasing 3 more neutrons. These go off and cause 3 more U-235 atoms to split, creating another 9 more neutrons. This will continue until there are no more atoms to split.

203. TRUE or FALSE: **(1 mark)**
ANSWER:
FALSE: Canadian reactors need the uranium to be enriched to 3% in order to work

204. What is the difference between nuclear fission and nuclear fusion. **(2 marks)**
ANSWER:
Fission splits a heavy atom like U-235 into two smaller fragments, releasing binding energy
Fusion joins two light atoms like H-3 into He-5, releasing binding energy.

205. TRUE or FALSE: **(1 mark)**
ANSWER:
FALSE: Fissionable atomic bombs require 90% U-238 in order to work.