A 2kg car has a forward thrust of 4N. It has a drag force of 3N.

9) What net horizontal force acts on it?

$$\sum F_{net} = (4N) + (-3N)$$

$$\boxed{\sum F_{net} = 1N}$$

10) Is the car in equilibrium horizontally?

$\boxed{\text{No.}}$ The car has a positive net horizontal force

11) What is the car's acceleration horizontally?

$$\sum F = m \cdot a \rightarrow 1N = 2kg \cdot a$$

$$a = \frac{1}{2}\frac{N}{kg} = \frac{1}{2}\frac{kg \cdot m/s^2}{kg} = \boxed{\frac{1}{2}\frac{m}{s^2}}$$

12) Does the car have constant horizontal velocity?

$\boxed{\text{No}}$ because the car has a constant acceleration of $0.5 \frac{m}{s^2}$

Velocity is not constant, but increasing at a rate of $0.5 \frac{m}{s^2}$.

A stone weighs 12N. It has an upward drag force of 5N.

13) What net vertical force acts on the stone?

$\uparrow + \downarrow \quad \sum F_{net} = (5N) + (-12N)$

$\boxed{\sum F_{net} = -7N}$

14) Is the stone in equilibrium vertically?

No because it has a negative net force of 7N

15) What is the stone's acceleration vertically?

$\sum F = ma \rightarrow -7N = m \cdot a \rightarrow a = \frac{-7N}{1.2kg} = \boxed{-5.83 \frac{m}{s^2}}$

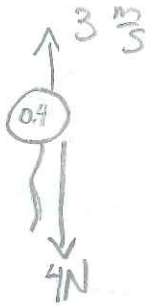
$w = mg = m = \frac{w}{g} \rightarrow m = \frac{12N}{10 \frac{N}{kg}} = 1.2Kg$

16) Does the stone have constant vertical velocity?

No it does not have a constant velocity because it's accelerating at $-5.83 \frac{m}{s^2}$

One Dimensional Motion, Acceleration and Net Force

A balloon is moving vertically. Its velocity is a constant +3m/s. It weighs 4N.



$w = mg \rightarrow m = \frac{w}{g} \rightarrow m = \frac{4N}{10\frac{N}{kg}} = 0.4kg$

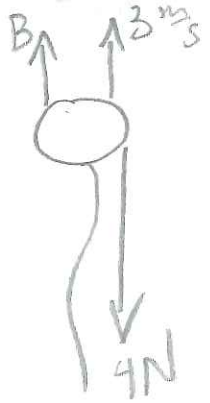
17) What is the balloon's acceleration in the vertical axis?

No vertical acceleration because it has a constant acceleration of $3\frac{m}{s}$

18) Is the balloon in equilibrium in the vertical axis?

Yes because its moving at a constant velocity of $3\frac{m}{s}$. No acceleration = equilibrium

19) What is the balloon's buoyant (upward) force?



$\sum F_{net} = B + (-4N)$

$0 = B - 4N$

$B = 4N$

Also if the balloon is in equilibrium, that means the sum of the forces must equal zero. A downward force of 4N must be countered by an upward force of 4N

A stone is falling vertically. Its velocity changes from -12m/s to -18m/s in 1s. The stone weighs 9N.

$$a = \frac{\Delta V}{\Delta T} = \frac{-18+12}{1} = \boxed{-6\,\frac{m}{s^2}}$$

20) What is the stone's acceleration in the vertical axis?

$$\boxed{a = -6\,\frac{m}{s^2}}$$

21) Is the stone in equilibrium in the vertical axis?

$\boxed{\text{No}}$ because there is acceleration of $-6\,\frac{m}{s^2}$

22) What is the stone's mass?

$$w = m \cdot g \rightarrow m = \frac{w}{g} \rightarrow \frac{9N}{10\,\frac{N}{Kg}} = \boxed{0.9Kg}$$

23) What is the stone's upward drag force?

$$\Sigma F_{net} = m \cdot a$$

$$\Sigma F_{net} = 0.9Kg \cdot \left(-6\,\frac{m}{s^2}\right)$$

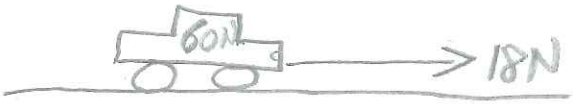
$$\Sigma F_{net} = -5.4N$$

$$\Sigma F_{net} = Drag + (-9N)$$

$$-5.4N + 9N = Drag$$

$$\boxed{Drag = +3.6N}$$

A 60N car's horizontal velocity changes from +4m/s to +8m/s in 2s. The car has a forward horizontal thrust of 18N.



24) What is the car's acceleration in the horizontal axis?

$$a = \frac{\Delta V}{\Delta T} = \frac{8\frac{m}{s} - 4\frac{m}{s}}{2s} = \boxed{2\frac{m}{s^2}}$$

25) Is the car in equilibrium in the horizontal axis?

$\boxed{\text{No}}$ because the car has an acceleration of $2\frac{m}{s^2}$

26) What is the car's mass?

$$w = m \cdot g \rightarrow m = \frac{w}{g} \rightarrow m = \frac{60N}{10\frac{N}{kg}} = \boxed{6kg}$$

27) What is the car's net horizontal force?

$$\sum F_{net} = m \cdot a \rightarrow \sum F_{net} = 6kg\left(2\frac{m}{s^2}\right)$$

$$\boxed{\sum F_{net} = 12N}$$

28) What is the car's Horizontal drag force?

$$\sum F_{net} = \text{Thrust} + \text{Drag}$$

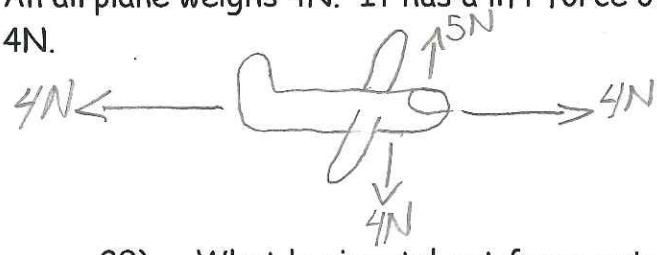
$$12N = 18N + \text{Drag}$$

$$\text{Drag} = 12N - 18N$$

$$\boxed{\text{Drag} = -6N}$$

Two Dimensional Net Force, Equilibrium and Acceleration

An airplane weighs 4N. It has a lift force of 5N. It has a thrust of 4N. It has a drag force of 4N.



29) What horizontal net force acts on the plane?

$\Sigma F_{hor\,net} = 4N + (-4N) = \boxed{\Sigma F_{hor} = 0N}$

30) Is the plane in equilibrium along the horizontal axis?

$\boxed{\text{Yes}}$ Since there are no horizontal External net forces

31) What is the plane's acceleration along the horizontal axis?

$\boxed{a = 0\,\frac{m}{s^2}}$ Since there are no horizontal net external forces

32) Does the plane have constant velocity along the horizontal axis?

$\boxed{\text{Yes}}$ because there is no acceleration horizontally

33) What vertical net force acts on the plane?

$\Sigma F_{vert} = 5N + (-4N)$

$\boxed{\Sigma F_{vert} = 1N}$

34) Is the plane in equilibrium along the vertical axis?

$\boxed{\text{No.}}$ because there is a net external force of 1N

35) What is plane's acceleration along the vertical axis?

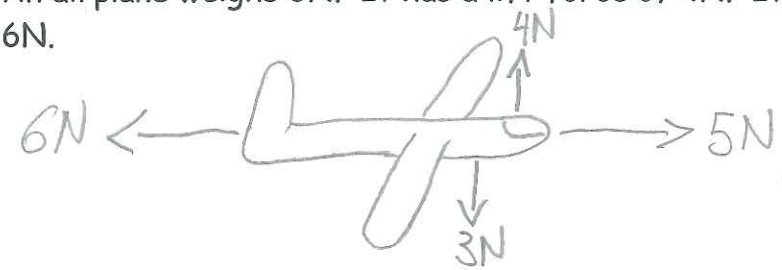
$w = m \cdot g \rightarrow m = \frac{w}{g} \rightarrow m = 0.4kg$

$\Sigma F_{vert} = m \cdot a \rightarrow a = \frac{\Sigma F_{vert}}{m} = \frac{1N}{0.4kg} = \boxed{a = 2.5\,\frac{m}{s^2}}$

36) Does the plane have constant velocity along the vertical axis?

$\boxed{\text{No}}$ because it has an acceleration of $2.5\,\frac{m}{s^2}$

An airplane weighs 3N. It has a lift force of 4N. It has a thrust of 5N. It has a drag force of 6N.



37) What horizontal net force acts on the plane?

$\sum F_{hor} = 5N + (-6N)$

$\boxed{\sum F_{hor} = -1N}$

38) Is the plane in equilibrium along the horizontal axis?

$\boxed{\text{No}}$ because of a net external horizontal force of $-1N$

39) What is the plane's acceleration along the horizontal axis?

$\sum F_{hor} = m \cdot a \rightarrow -1N = 0.3Kg \cdot a \rightarrow a = \frac{-1N}{0.3Kg}$

$w = mg \rightarrow m = \frac{w}{g} \rightarrow m = 0.3Kg$

$\boxed{a = -3.3 \frac{m}{s^2}}$

40) Does the plane have constant velocity along the horizontal axis?

$\boxed{\text{No}}$ because it has a net external force

41) What vertical net force acts on the plane?

$\sum F_{vert} = 4N - 3N \rightarrow \boxed{\sum F_{vert} = 1N}$

42) Is the plane in equilibrium along the vertical axis?

$\boxed{\text{No}}$ because it has a net external vertical force

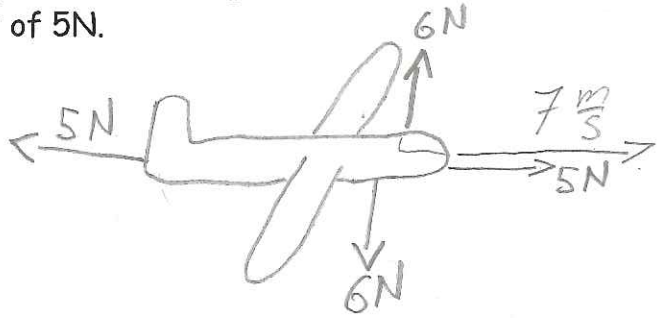
43) What is the plane's acceleration along the vertical axis?

$\sum F_{vert} = m \cdot a \rightarrow a = \frac{\sum F_{vert}}{m} \rightarrow \boxed{a = 3.3 \frac{m}{s^2}}$

44) Does the plane have constant velocity along the vertical axis?

$\boxed{\text{No}}$ because of its vertical acceleration

An airplane flies straight and level with a constant speed of 7m/s. It weighs 6N and has a thrust of 5N.



45) What is the plane's acceleration along the horizontal axis?

$\boxed{a = 0 \frac{m}{s^2}}$ because of its constant speed of $7 \frac{m}{s}$

46) Is the plane in equilibrium along the horizontal axis?

$\boxed{\text{Yes.}}$ no acceleration = no net external forces = equilibrium

47) What horizontal net force acts on the plane?

$\boxed{0N}$ of net horizontal forces Since it's in equilibrium

48) What drag force must act on the plane?

5N of drag force since

$\sum F = \text{Thrust} + \text{Drag} \rightarrow \boxed{\text{Drag} = -5N}$

49) What is the plane's acceleration along the vertical axis?

$\boxed{\text{No acceleration}}$ in the vertical axis since its flying leve

50) Is the plane in equilibrium along the vertical axis?

$\boxed{\text{Yes}}$ Since there is no acceleration = no external net forces

51) What vertical net force acts on the plane?

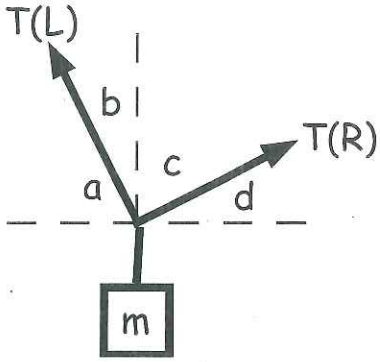
No vertical net forces since the plane is in equilibrium

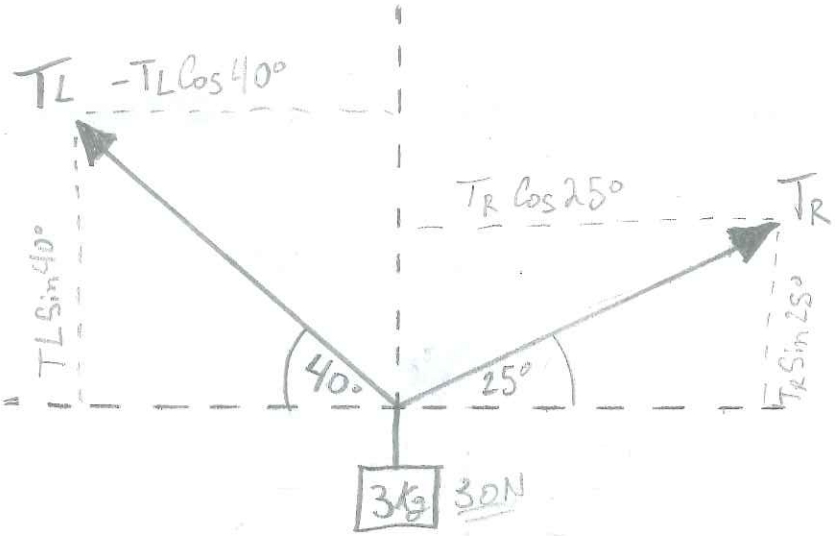
52) What lift force must act on the plane?

$\sum F_{vert} = F_{weight} + F_{lift}$

$0 = -6N + F_{Lift}$ $\boxed{F_{Lift} = 6N}$

Statics (1)





Two cords, as shown in the diagram, support a traffic light. The value of m is 3kg. Angle 'a' is 40 degrees. Angle 'd' is 25 degrees.

53) Find the value of T(L) by applying Newton's First Law horizontally and then vertically. Use simultaneous equations to solve.

$? \rightarrow \sum F_h = 0 \therefore \quad -T_L \cos 40° + T_R \cos 25° = 0$

$T_R \cos 25° = T_L \cos 40$

$T_R = \dfrac{T_L \cos 40°}{\cos 25°}$

$? \rightarrow \sum F_v = 0 \therefore \quad (T_L \sin 40°) + (T_R \sin 25°) + (-30N) = 0$

$(T_L \sin 40°) + \left[\left(\dfrac{T_L \cos 40}{\cos 25}\right)(\sin 25°)\right] = 30N$

$T_L 0.643 + T_L 0.357 = 30$

$T_L = \dfrac{30}{.643 + .357}$ $\quad \boxed{T_L = 30N}$

54) Find the value of T(R) by substitution.

$T_R = \dfrac{T_L \cos 40°}{\cos 25°} \rightarrow T_R = \dfrac{30(\cos 40)}{\cos 25}$

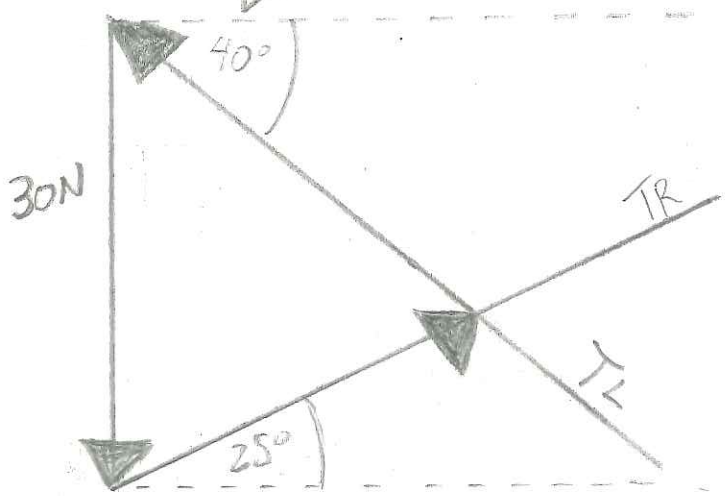
$\boxed{T_R = 25.4N}$

55) Check your answers to Q53 and Q54 using a scaled vector diagram.

30N = 6cm

$5 \frac{N}{cm}$

How do get that consistently



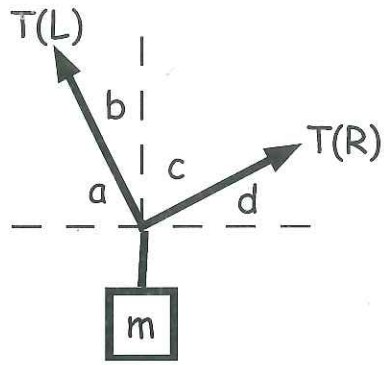
measurement = 5.15 cm

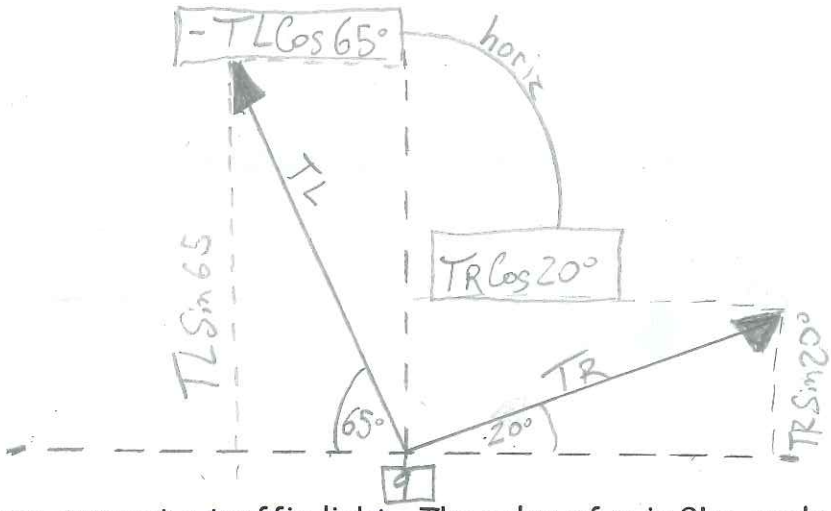
TR

$5.15 cm \cdot 5 \frac{N}{cm} = \boxed{25.75} N$

TL

$6 cm \cdot 5 \frac{N}{cm} = \boxed{30N}$





Two cords, as shown in the diagram, support a traffic light. The value of m is 9kg, angle 'a' is 65 degrees and angle 'd' is 20 degrees.

56) Find the value of T(L) by applying Newton's First Law horizontally and then vertically. Use simultaneous equations to solve.

$$\Sigma F_{hor} = 0 \therefore \quad (-T_L \cos 65°) + (T_R \cos 20°) = 0$$

$$T_R = \frac{T_L \cos 65°}{\cos 20°}$$

$$\Sigma F_{vert} = 0 \therefore \quad (T_L \sin 65°) + (T_R \sin 20°) + (-90N) = 0$$

$$(T_L \sin 65°) + \left[\frac{T_L \cos 65}{\cos 20} \cdot \sin 20°\right] = 90N$$

$$(0.90631 T_L) + (0.15382 T_L) = 90N$$

$$T_L = \frac{90N}{(0.90631) + (0.15382)}$$

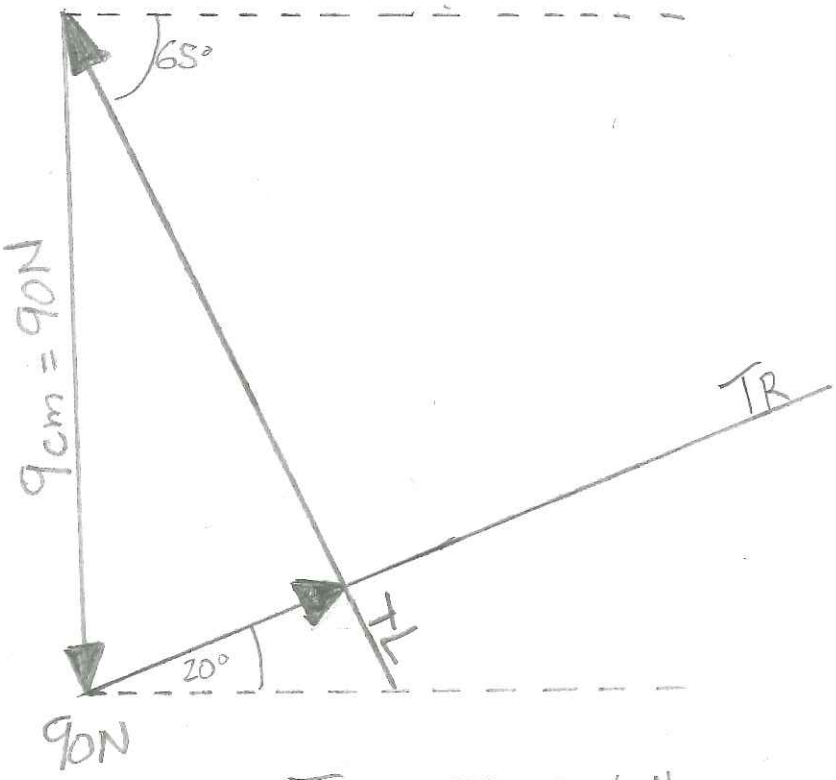
$$\boxed{T_L = 84.90N}$$

57) Find the value of T(R) by substitution.

$$T_R = \frac{T_L \cos 65°}{\cos 20°} = \frac{(84.90)(\cos 65)}{\cos 20}$$

$$\boxed{T_R = 38.13N}$$

58) Check your answers to Q56 and Q57using a scaled vector diagram.

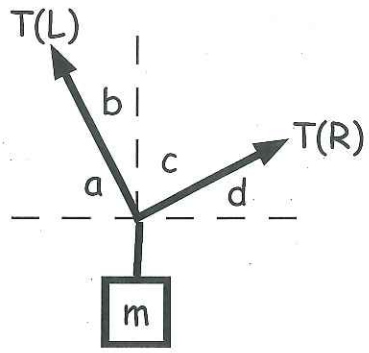


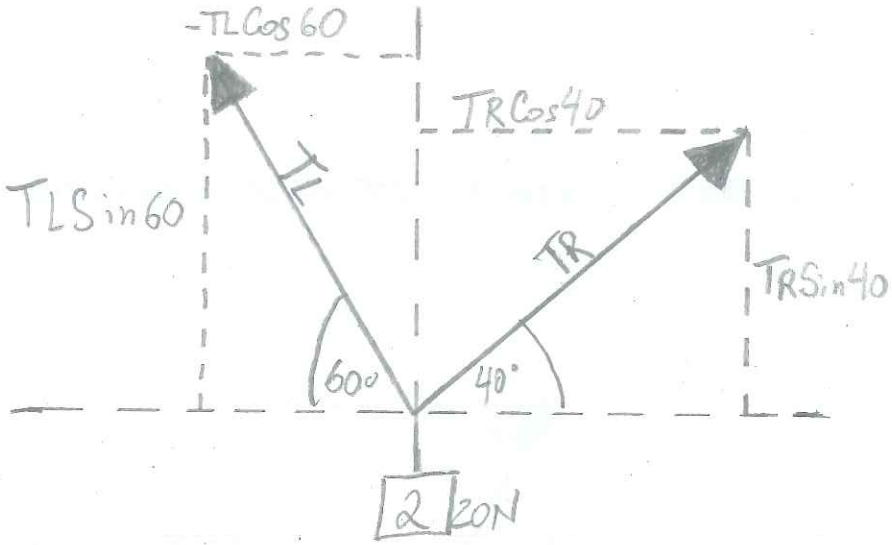
$T_R = 3.75cm \cdot 10\frac{N}{cm}$

$\boxed{T_R = 37.5N}$

$T_L = 8.45cm \cdot 10\frac{N}{cm}$

$\boxed{T_L = 84.5N}$





Two cords, as shown in the diagram, support a traffic light. The value of m is 2kg, angle 'a' is 60 degrees and angle 'c' is 50 degrees.

59) Find the value of T(R) by applying Newton's First Law horizontally and then vertically. Use simultaneous equations to solve.

$$\sum F_{hor} = 0 \therefore \quad (-TL\cos 60) + (TR\cos 40°) = 0$$

$$TR = \frac{TL\cos 60}{\cos 40}$$

$$\sum F_{vert} = 0 \therefore \quad (TL\sin 60) + (TR\sin 40) + (-20N) = 0$$

$$(TL\sin 60) + \left[\frac{TL\cos 60}{\cos 40} \cdot \sin 40\right] = 20N$$

$$(TL\,0.8660) + (TL\,0.41955) = 20N$$

$$TL = \frac{20N}{(0.8660) + (0.41955)}$$

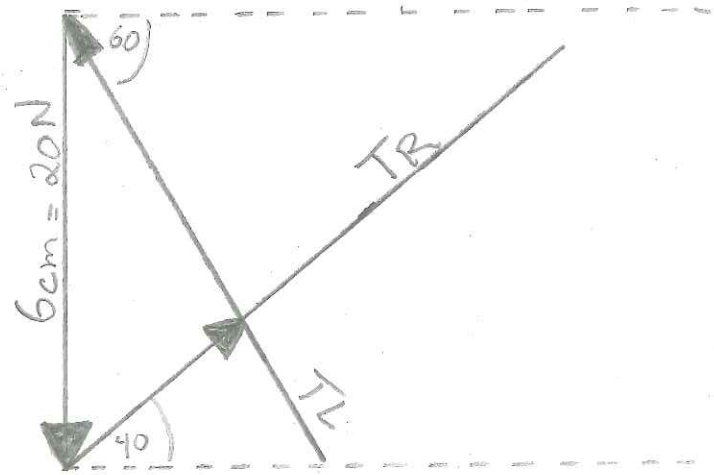
$$\boxed{TL = 15.56N}$$

60) Find the value of T(L) by substitution.

$$TR = \frac{TL\cos 60}{\cos 40} = \frac{(15.56N)(\cos 60)}{\cos 40}$$

$$\boxed{TR = 10.15N}$$

61) Check your answers to Q59 and Q60 using a scaled vector diagram.

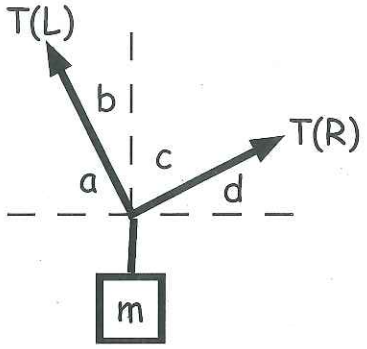


$T_R = 3.10\,cm \cdot 3.33\,\frac{N}{cm}$

$\boxed{T_R = 10.33N}$

$T_L = 4.70\,cm \cdot 3.33\,\frac{N}{cm}$

$\boxed{T_L = 15.67N}$

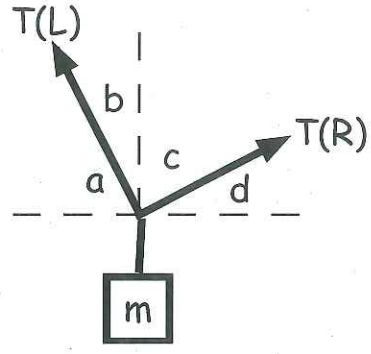


Two cords, as shown in the diagram, support a traffic light. The value of m is 3kg, angle 'b' is 20 degrees and angle 'c' is 55 degrees.

62) Find the value of T(R) by applying Newton's First Law horizontally and then vertically. Use simultaneous equations to solve.

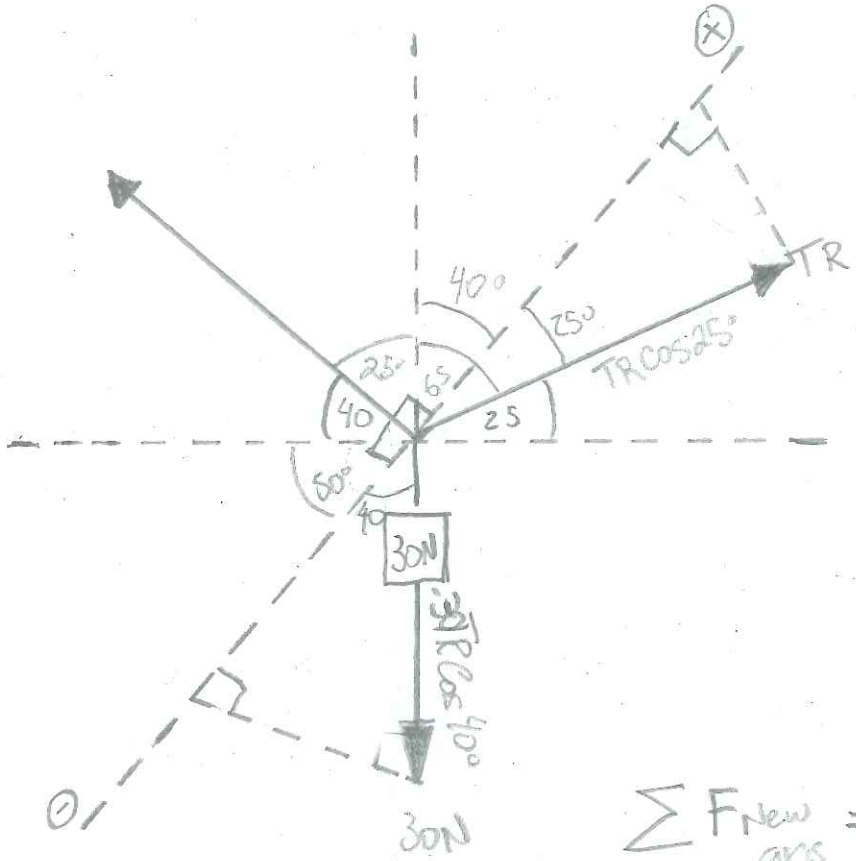
63) Find the value of T(L) by substitution.

64) Check your answers to Q62 and Q63 using a scaled vector diagram.



Two cords, as shown in the diagram, support a traffic light. The value of m is 3kg. Angle 'a' is 40 degrees. Angle 'd' is 25 degrees.

65) Find T(R) in one step by applying Newton's First Law along an axis that is perpendicular to T(L).

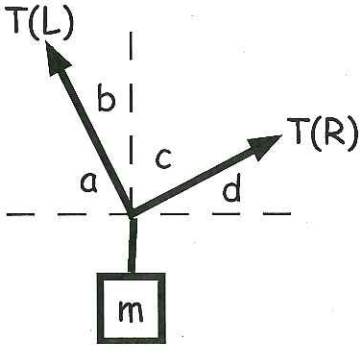


$$\sum F_{\text{New axis}} = 0$$

$$(T_R \cos 25°) + (-30 \cos 40°) = 0$$

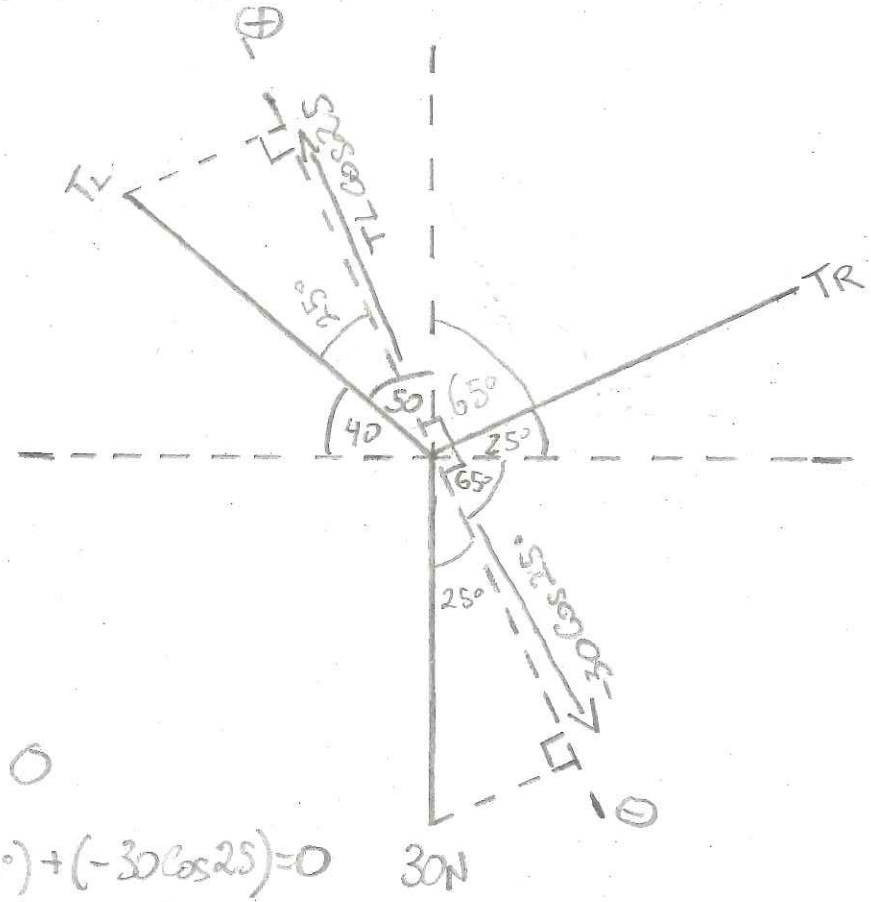
$$T_R = \frac{30 \cos 40}{\cos 25°}$$

$$\boxed{T_R = 25.36\text{N}}$$



Two cords, as shown in the diagram, support a traffic light. The value of m is 3kg. Angle 'a' is 40 degrees. Angle 'd' is 25 degrees.

66) Find T(L) in one step by applying Newton's First Law along an axis that is perpendicular to T(R).



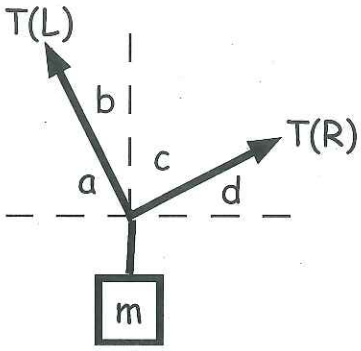
How do you pick b/w Sin/Cos for new line?

$$\sum F_{\substack{New \\ axis}} = 0$$

$$(TL \cos 25°) + (-30 \cos 25) = 0$$

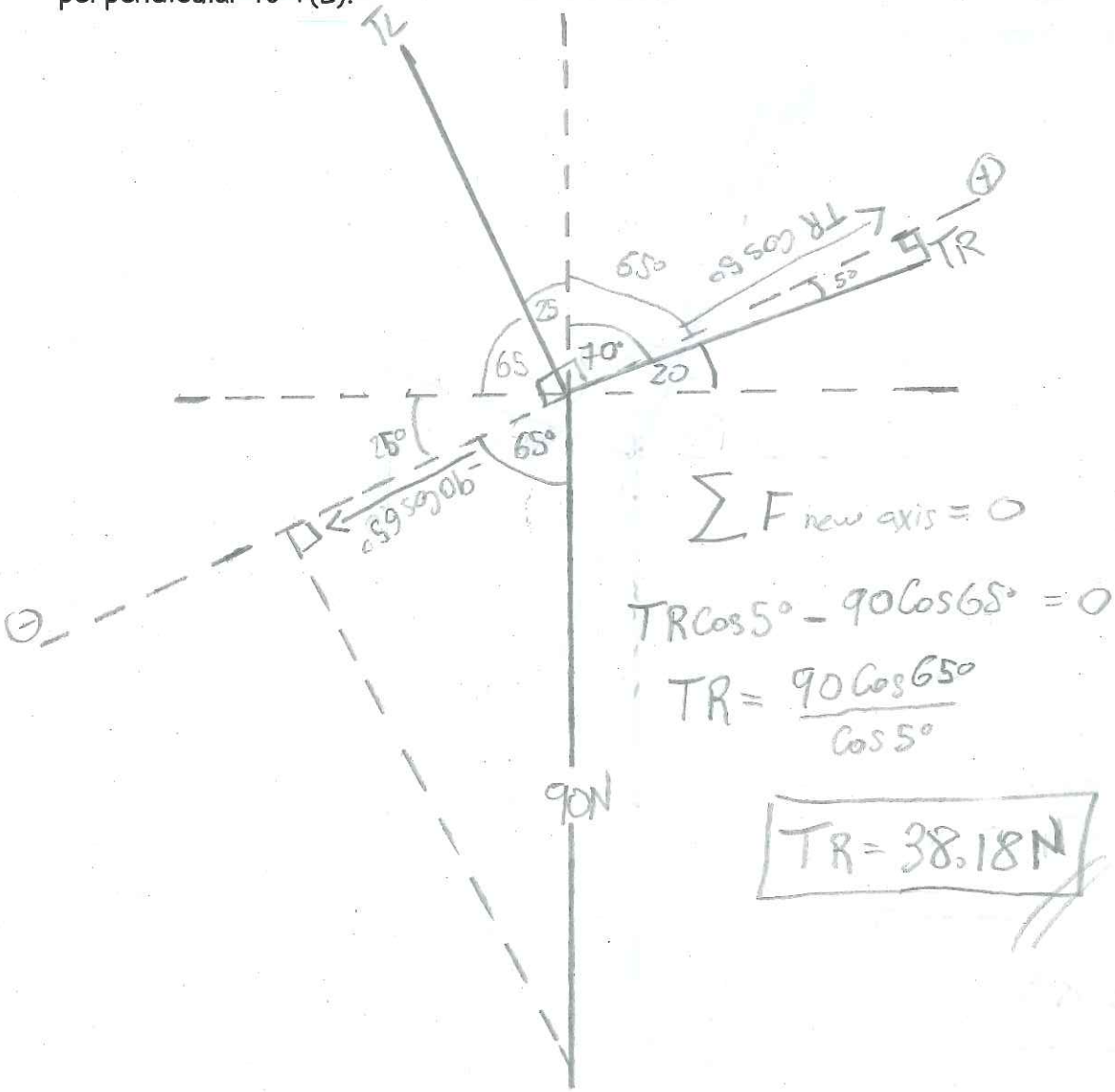
$$TL = \frac{30 \cos 25}{\cos 25}$$

$$\boxed{TL = 30N}$$



Two cords, as shown in the diagram, support a traffic light. The value of m is 9kg, angle 'a' is 65 degrees and angle 'd' is 20 degrees.

67) Find T(R) in one step by applying Newton's First Law along an axis that is perpendicular to T(L).

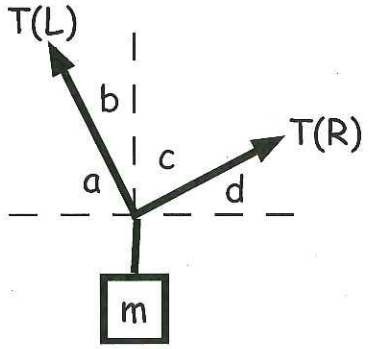


$$\sum F_{\text{new axis}} = 0$$

$$TR\cos 5° - 90\cos 65° = 0$$

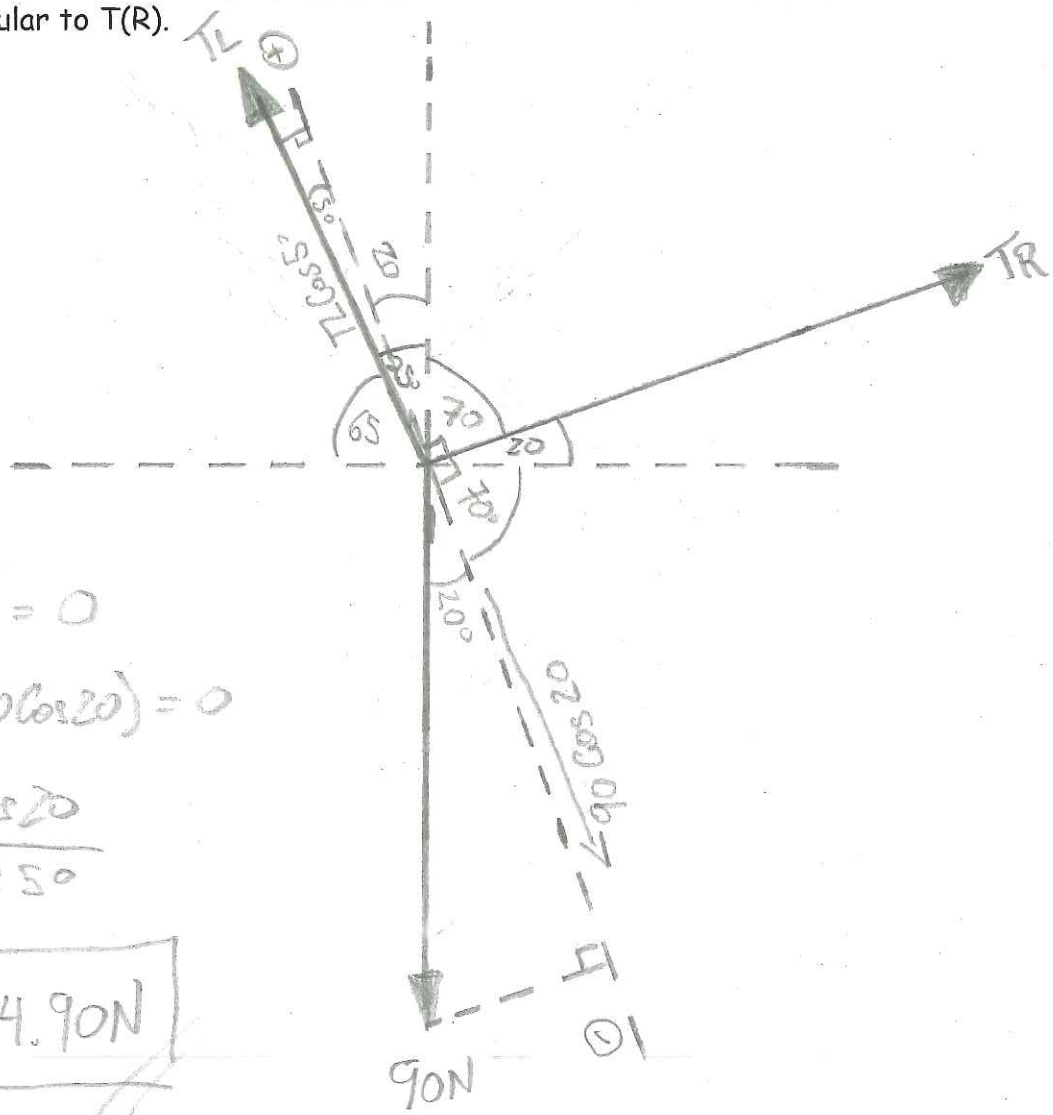
$$TR = \frac{90\cos 65°}{\cos 5°}$$

$$\boxed{TR = 38.18N}$$



Two cords, as shown in the diagram, support a traffic light. The value of m is 9kg, angle 'a' is 65 degrees and angle 'd' is 20 degrees.

68) Find T(L) in one step by applying Newton's First Law along an axis that is perpendicular to T(R).

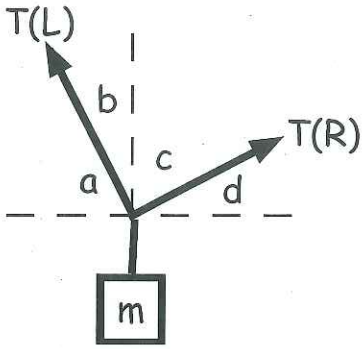


$$\sum F_{\text{new axis}} = 0$$

$$(T_L \cos 5^\circ) + (-90 \cos 20) = 0$$

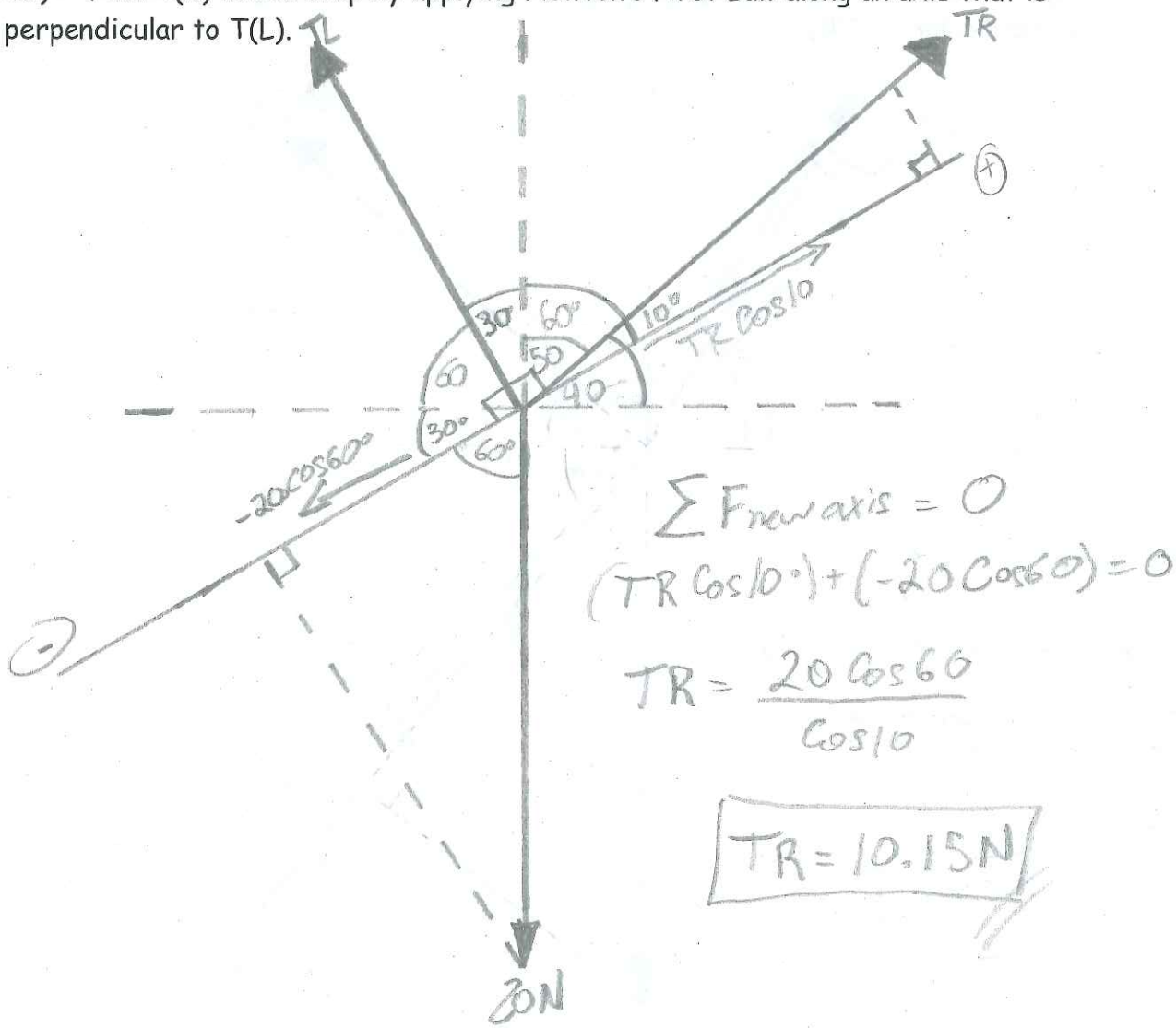
$$T_L = \frac{90 \cos 20}{\cos 5^\circ}$$

$$\boxed{T_L = 84.90\text{N}}$$



Two cords, as shown in the diagram, support a traffic light. The value of m is 2kg, angle 'a' is 60 degrees and angle 'c' is 50 degrees.

69) Find T(R) in one step by applying Newton's First Law along an axis that is perpendicular to T(L).

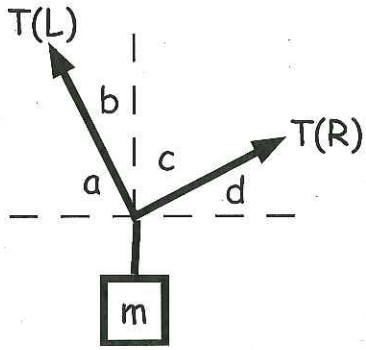


$$\sum F_{new\ axis} = 0$$

$$(TR\ Cos10°) + (-20\ Cos60) = 0$$

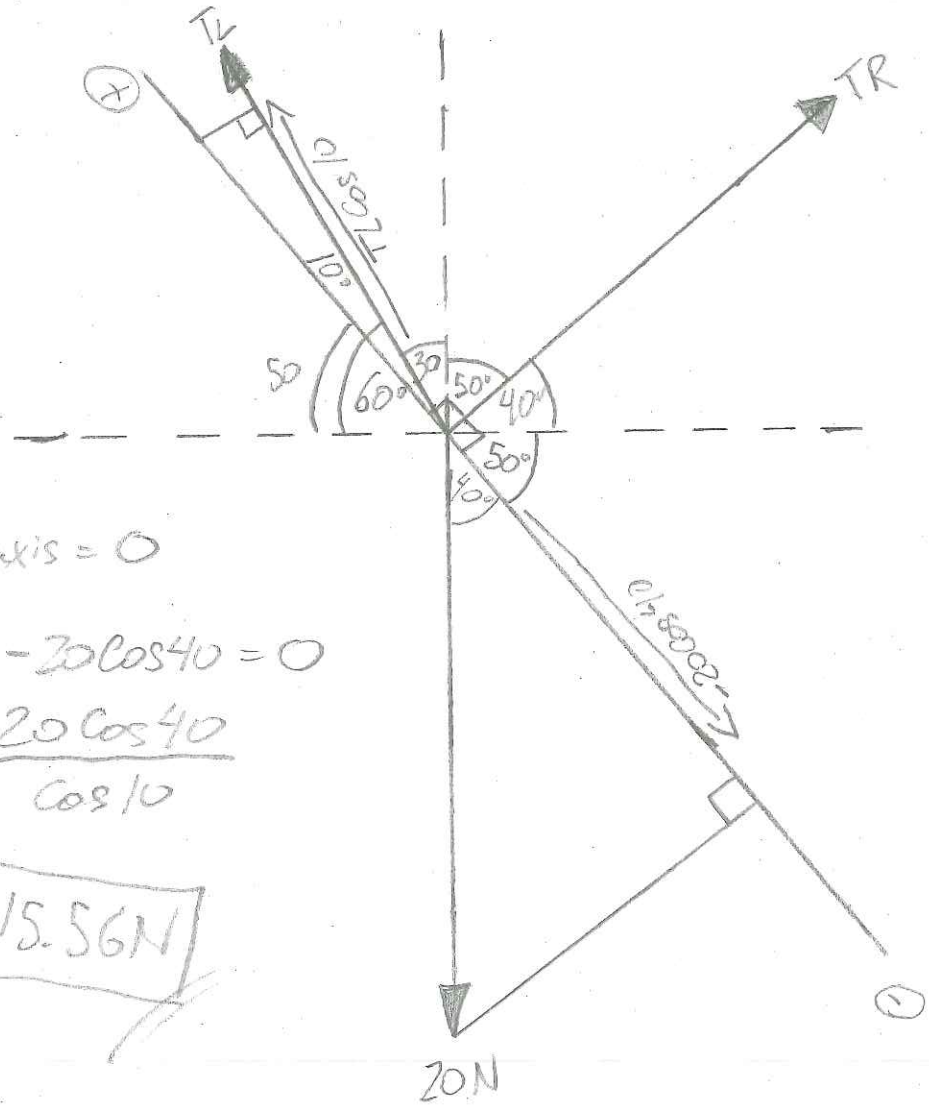
$$TR = \frac{20\ Cos60}{Cos10}$$

$$\boxed{TR = 10.15N}$$



Two cords, as shown in the diagram, support a traffic light. The value of m is 2kg, angle 'a' is 60 degrees and angle 'c' is 50 degrees.

70) Find T(L) in one step by applying Newton's First Law along an axis that is perpendicular to T(R).

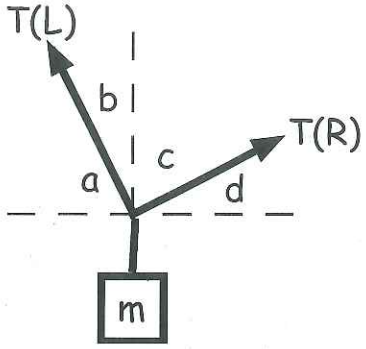


$\sum F_{new\ axis} = 0$

$T_L \cos 10 - 20 \cos 40 = 0$

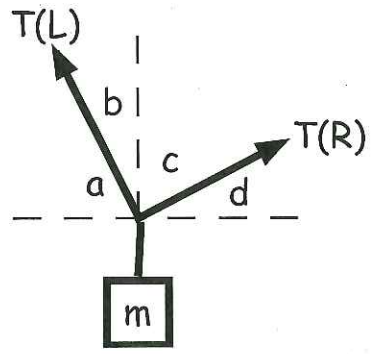
$T_L = \dfrac{20 \cos 40}{\cos 10}$

$\boxed{T_L = 15.56N}$



Two cords, as shown in the diagram, support a traffic light. The value of m is 3kg, angle 'b' is 20 degrees and angle 'c' is 55 degrees.

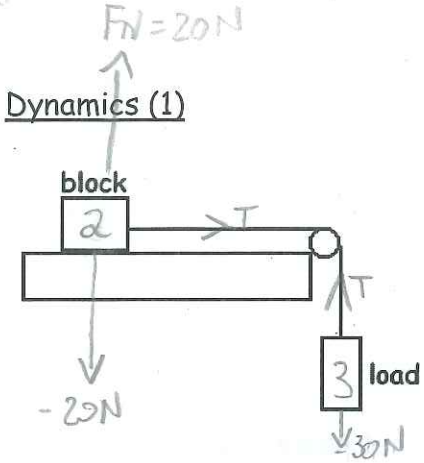
71) Find T(R) in one step by applying Newton's First Law along an axis that is perpendicular to T(L).



Two cords, as shown in the diagram, support a traffic light. The value of m is 3kg, angle 'b' is 20 degrees and angle 'c' is 55 degrees.

72) Find T(L) in one step by applying Newton's First Law along an axis that is perpendicular to T(R).

Dynamics (1)



A 3 kg load, and a 2 kg block, are attached by a lightweight string that passes over a frictionless pulley of negligible mass. The block lies on a level frictionless surface.

73) Find the acceleration of the load once the system is released.

Why is the down force positive?

$\sum F_{sys} = m_{sys} \cdot a_{sys}$

$30 = (2+3) \cdot a \rightarrow \frac{30}{5} = a \rightarrow \boxed{a_{sys} = 6 \frac{m}{s^2}}$

74) Once the system is released, how does the acceleration of the load compare with the acceleration of the block?

$a_{Load} = a_{Block} = a_{sys}$

IF YOU USED LOAD

$\sum F = ma$

$(+30) + (-T) = 3(6)$

$T = 30 - 18 = 12N$

75) Find the tension in the string once the system is released.

Why find T for Block instead of T for load?

$\sum F_2 = m_2 \cdot a_2 \rightarrow T = 2 \cdot 6 \rightarrow \boxed{T = 12N}$

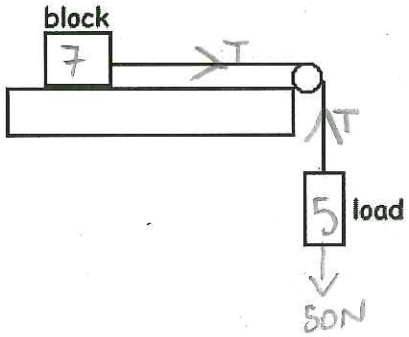
76) What is the tension in the string before the system is released?

Before the system is released = no acceleration

Why use the load here?

$\therefore \underbrace{\sum F_y}_{\text{why?}} = 0 \rightarrow (+T) + (-30) = 0$

$\boxed{T = 30N}$



A 5 kg load, and a 7 kg block, are attached by a lightweight string that passes over a frictionless pulley of negligible mass. The block lies on a level frictionless surface.

77) Find the acceleration of the load once the system is released.

$\sum F_{sys} = m_{sys} \cdot a_{sys} \longrightarrow 50N = (7+5) \cdot a_{sys}$

$a_{sys} = \frac{50N}{12kg} = \boxed{4.17 \frac{m}{s^2}}$

78) Find the tension in the string once the system is released.

$\sum F_{Block} = m_{Block} \cdot a_{Block}$

$T = 7kg \cdot 4.17 \frac{m}{s^2}$

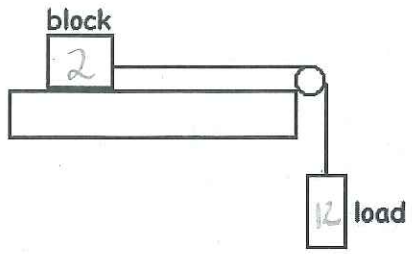
$\boxed{T = 29.19}$

79) What is the tension in the string before the system is released?

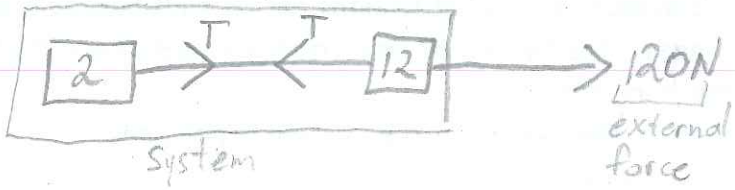
$\sum F_y = 0$ because there is no acceleration

$T + (-50N) = 0$

$\boxed{T = 50N}$



A 12 kg load, and a 2 kg block, are attached by a lightweight string that passes over a frictionless pulley of negligible mass. The block lies on a level frictionless surface.



80) Find the acceleration of the load once the system is released.

$$\sum F_{sys} = m_{sys} \cdot a_{sys}$$

$$12N = (2+12) \cdot a_{sys}$$

$$a_{sys} = \frac{120N}{14Kg} \longrightarrow \boxed{a_{sys} = 8.57 \frac{m}{s^2}}$$

81) Find the tension in the string once the system is released.

$$\sum F_{Block} = m_{Block} \cdot a_{Block}$$

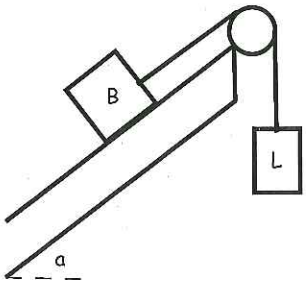
$$T = 2Kg \cdot \left(8.57 \frac{m}{s^2}\right)$$

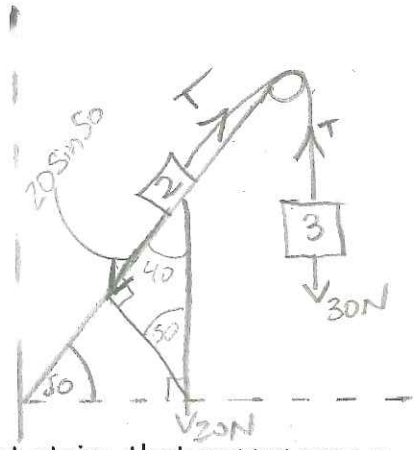
$$\boxed{T = 17.14 N}$$

82) What is the tension in the string before the system is released?

$$T + (-120N) = 0$$

$$\boxed{T = 120N}$$





A 3 kg load, and a 2 kg block, are attached by a lightweight string that passes over a frictionless pulley of negligible mass. The block lies on a frictionless surface that is inclined at an angle of 50 degrees above the horizontal.

83) Find the acceleration of the load once the system is released.

Why is 20sin50 negative here ?

$\sum F_{sys} = m_{sys} \cdot a_{sys} \rightarrow (30N) + (-20\sin 50) = (2+3) \cdot a_{sys}$

$\frac{30 - 20\sin 50}{5} = a_{sys} \rightarrow \boxed{a_{sys} = 2.94 \frac{m}{s^2}}$

84) Find the tension in the string once the system is released.

Why find T using load instead of Block ?

$\sum F_{Load} = m_{Load}\, a_{Load} \rightarrow (30) - T = 3(2.94)$

$T = 30 - 8.82$

$\boxed{T = 21.18N}$

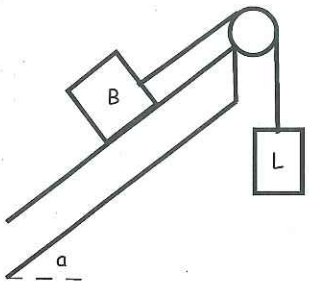
85) What is the tension in the string before the system is released?

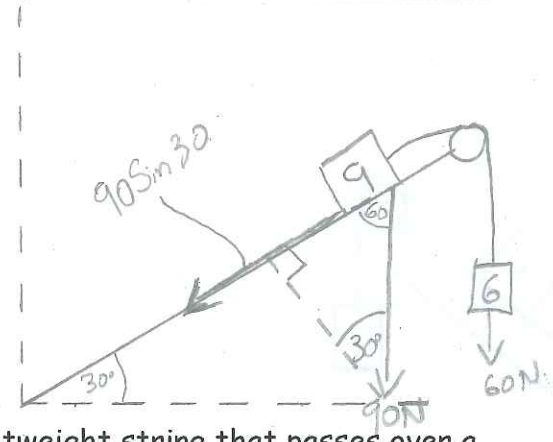
No acceleration before system is released

$\sum F_y = 0$

$T + (-30N) = 0$

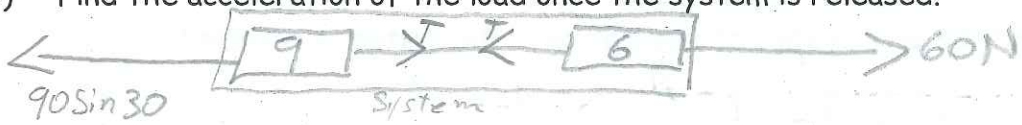
$\boxed{T = 30N}$





A 6 kg load, and a 9 kg block, are attached by a lightweight string that passes over a frictionless pulley of negligible mass. The block lies on a frictionless surface that is inclined at an angle of 30 degrees above the horizontal.

86) Find the acceleration of the load once the system is released.



$$\sum F_{sys} = m_{sys} \cdot a_{sys} \rightarrow 60N - 90\sin 30 = (9+6)\, a_{sys}$$

$$a_{sys} = \frac{60 - 90\sin 30}{15} \rightarrow \boxed{a_{sys} = 1\ \frac{m}{s^2}}$$

87) Find the tension in the string once the system is released.

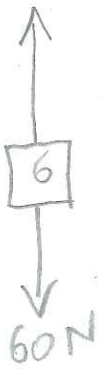
$$\sum F_{load} = m_{load} \cdot a_{load}$$

$$-T + 60N = 6 \cdot 1$$

$$T = 60N - 6N$$

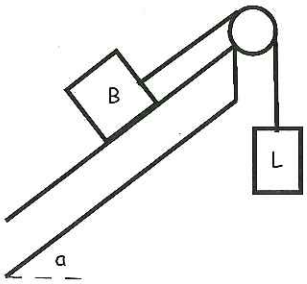
$$\boxed{T = 54N}$$

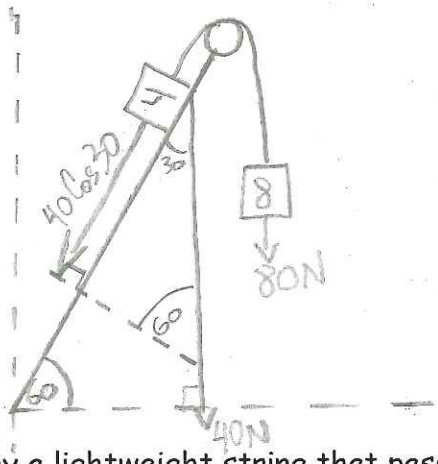
88) What is the tension in the string before the system is released?



$$T - 60N = 0$$

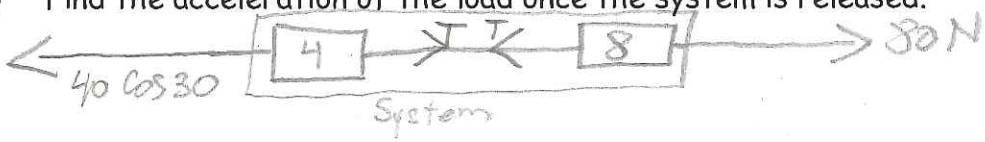
$$\boxed{T = 60N}$$





An 8 kg load, and a 4 kg block, are attached by a lightweight string that passes over a frictionless pulley of negligible mass. The block lies on a frictionless surface that is inclined at an angle of 60 degrees above the horizontal.

89) Find the acceleration of the load once the system is released.



$$\sum F_{sys} = m_{sys} \cdot a_{sys} \rightarrow 80N - 40\cos 30 = (4+8)a$$

$$a_{sys} = \frac{80N - 40\cos 30}{12} \rightarrow \boxed{a_{sys} = 3.78 \frac{m}{s^2}}$$

90) Find the tension in the string once the system is released.

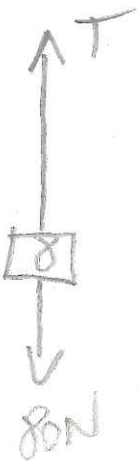
$$\sum F_{load} = m_{load} \cdot a_{load}$$

$$-T + 80N = 8kg\,(3.78\,m/s^2)$$

$$T = 80N - 30.24N$$

$$\boxed{T = 49.76N}$$

91) What is the tension in the string before the system is released?



$$\sum F_v = 0$$

$$T - 80N = 0$$

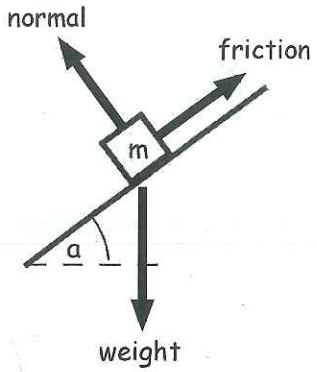
$$\boxed{T = 80N}$$

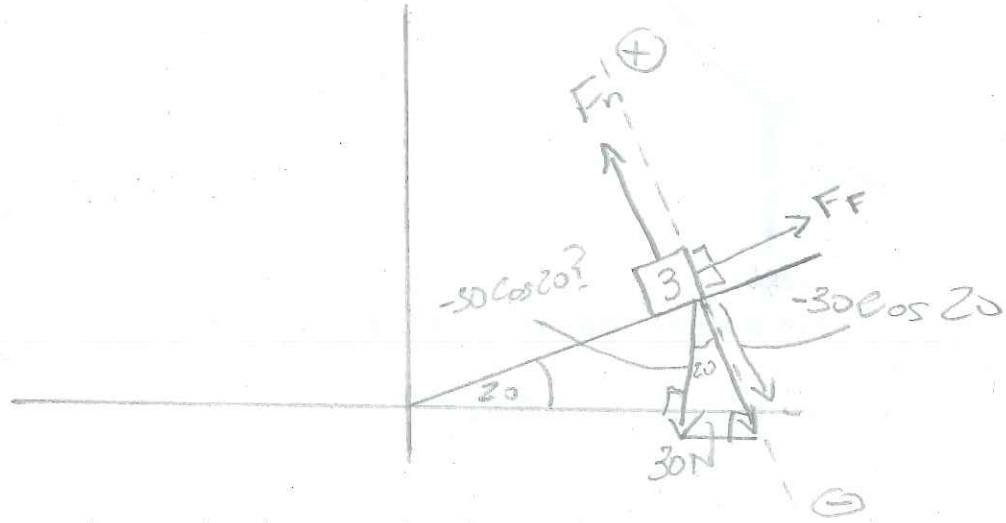
NEWTON'S LAWS ANSWERS

1) 0N
2) YES
3) $0 m/s^2$
4) YES
5) 0N
6) YES
7) $0 m/s^2$
8) YES
9) +1.0N
10) NO
11) $+0.5 m/s^2$
12) NO
13) -7.0N
14) NO
15) $-5.8 m/s^2$
16) NO
17) $0 m/s^2$
18) YES
19) +4.0N
20) $-6.0 m/s^2$
21) NO
22) 0.9kg
23) +3.6N
24) $+2.0 m/s^2$
25) NO
26) 6.0kg
27) +12.0N
28) -6.0N
29) 0N
30) Yes
31) $0 m/s^2$
32) Yes
33) +1.0N
34) No
35) $+2.5 m/s^2$
36) No
37) -1.0N
38) No
39) $-3.3 m/s^2$
40) No
41) +1.0N
42) No
43) $+3.3 m/s^2$
44) No
45) $0 m/s^2$
46) Yes
47) 0N
48) -5.0N
49) $0 m/s^2$
50) Yes
51) 0N
52) 6.0N
53) 30.0N
54) 25.4N
55) See key
56) 84.9N
57) 38.2N
58) See key
59) 10.2N
60) 15.6N
61) See key
62) 10.6N
63) 25.4N
64) See key
65) 25.4N
66) 30.0N
67) 38.2N
68) 84.9N
69) 10.2N
70) 15.4N
71) 10.6N
72) 25.4N
73) $+6.0 m/s^2$
74) Same
75) 12.0N
76) 30.0N
77) $4.2 m/s^2$
78) 29.2N
79) 50.0N
80) $8.6 m/s^2$
81) 17.1N
82) 120N
83) $2.9 m/s^2$
84) 21.2N
85) 30.0N
86) $1.0 m/s^2$
87) 54.0N
88) 60.0N
89) $3.8 m/s^2$
90) 49.8N
91) 80.0N

2048 Laws of Motion Part 2 Homework

Statics (2)





A 3kg block is stationary on a slope. The slope is inclined at 20 degrees above the horizontal.

1) What is the normal force?

To ignore F_F, choose an axis that is perpendicular to F_F & resolve the forces along that axis with $\Sigma F = 0$

$(+F_N) + (-30\cos 20) = 0$

$F_n = 30\cos 20$

$\boxed{F_n = 28.19N}$

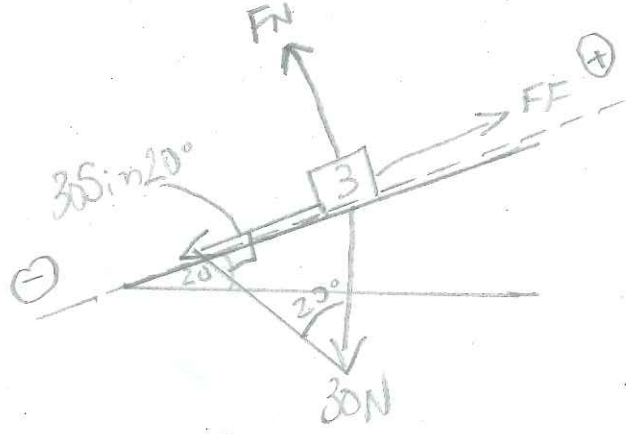
2) What is the frictional force?

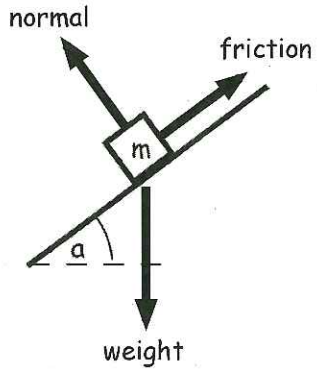
$\Sigma F = 0$

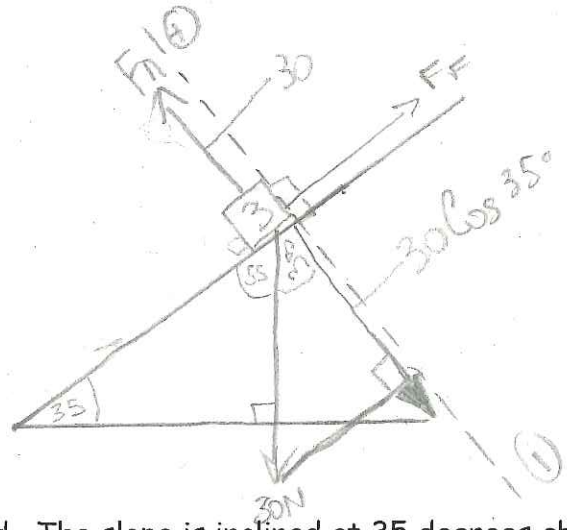
$F_F - 30\sin 20 = 0$

$F_F = 30\sin 20$

$\boxed{F_F = 10.26N}$







A 3kg block slides down a slope at a constant speed. The slope is inclined at 35 degrees above the horizontal.

3) What is the normal force?

$$\sum F = 0$$

$$F_N - 30\cos 35° = 0$$

$$F_N = 30\cos 35$$

$$\boxed{F_N = 24.57\,N}$$

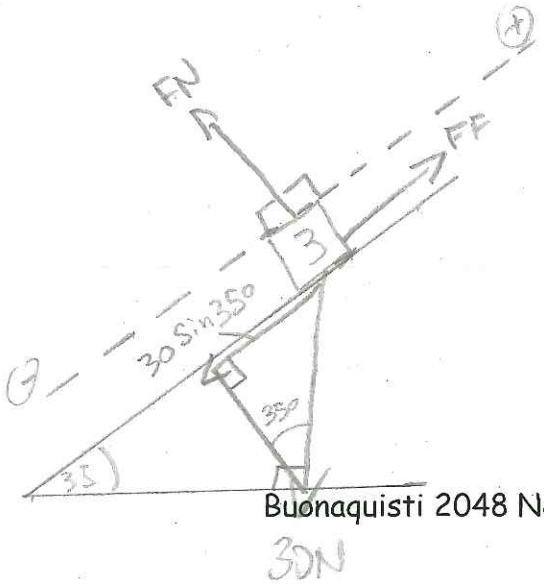
4) What is the frictional force?

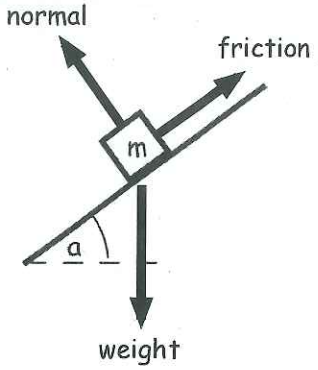
$$\sum F = 0$$

$$F_F - 30\sin 35° = 0$$

$$F_F = 30\sin 35°$$

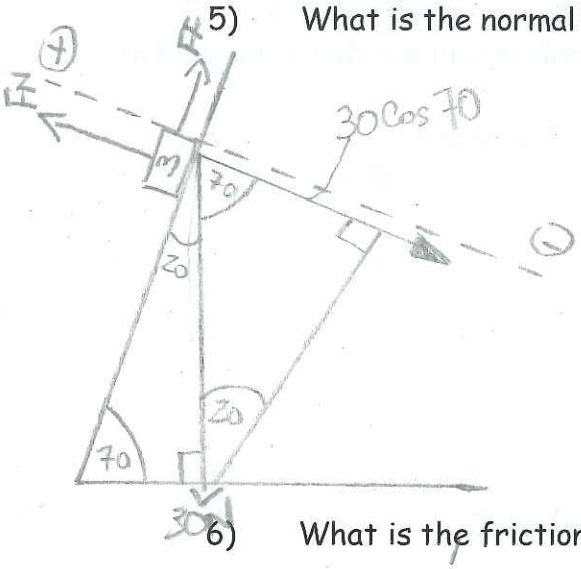
$$\boxed{F_F = 17.21\,N}$$





A 3kg block is stationary on a slope. The slope is inclined at 70 degrees above the horizontal.

5) What is the normal force?



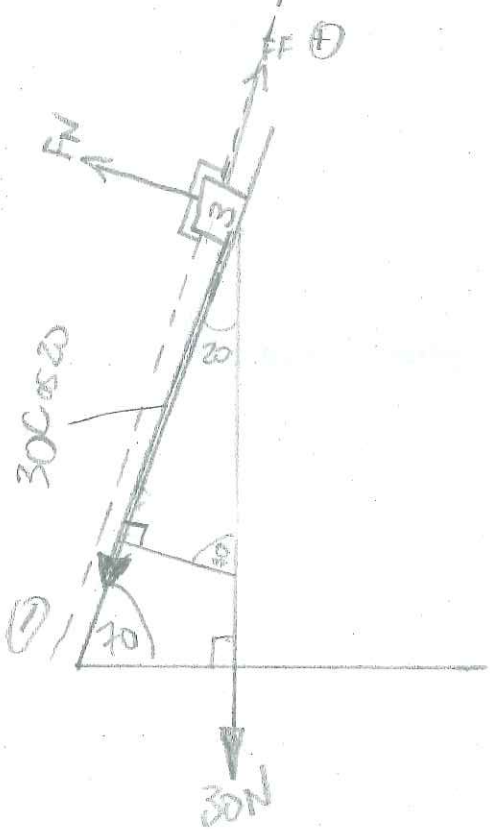
$\sum F = 0$

$F_N - 30\cos 70 = 0$

$F_N = 30\cos 70$

$\boxed{F_N = 10.26\,N}$

6) What is the frictional force?



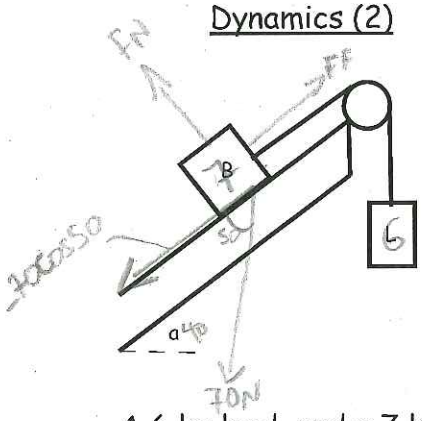
$\sum F = 0$

$F_F - 30\cos 20 = 0$

$F_F = 30\cos 20$

$\boxed{F_F = 28.19\,N}$

Dynamics (2)



A 6 kg load, and a 7 kg block, are attached by a lightweight string that passes over a frictionless pulley of negligible mass. The block lies on a frictionless surface that is inclined at an angle of 40 degrees above the horizontal.

7) Find the acceleration of the load once the system is released.

$$\sum F_{sys} = m_{sys} \cdot a_{sys} \longrightarrow -70\cos 50 + 60N = (7+6) \cdot a$$

$$a_{sys} = \frac{-70\cos 50 + 60N}{13} \longrightarrow \boxed{a_{sys} = 1.15 \frac{m}{s^2}}$$

8) Find the tension in the string once the system is released.

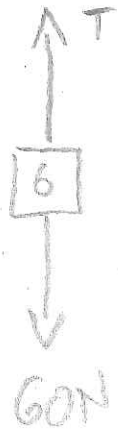
$$\sum F_{Load} = m_{Load} \cdot a_{Load}$$

$$-T + 60N = 6(1.15)$$

$$T = 60N - 6.9$$

$$\boxed{T = 53.1N}$$

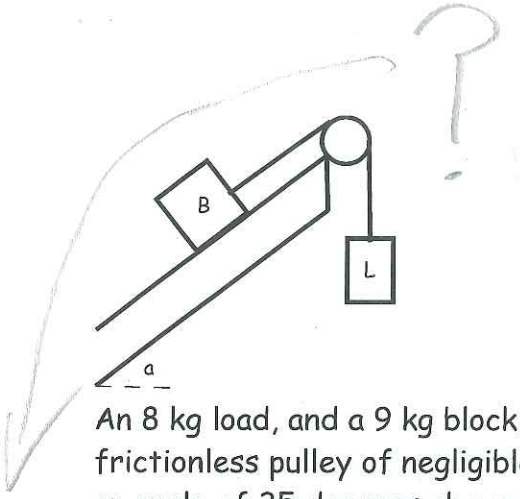
9) What is the tension in the string before the system is released?

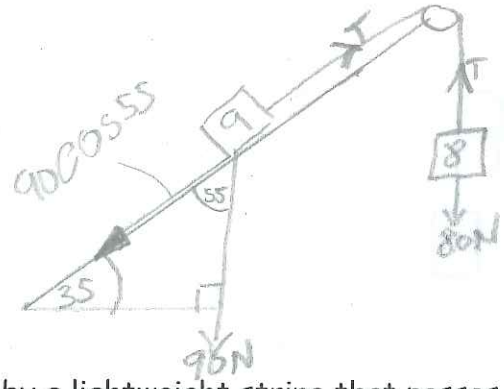


No acceleration $\therefore \sum F_v = 0$

$$T + (-60N) = 0$$

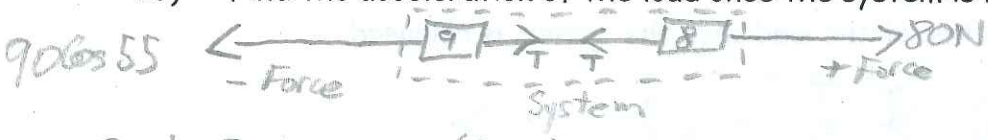
$$\boxed{T = 60N}$$





An 8 kg load, and a 9 kg block, are attached by a lightweight string that passes over a frictionless pulley of negligible mass. The block lies on a frictionless surface that is inclined at an angle of 35 degrees above the horizontal.

10) Find the acceleration of the load once the system is released.



$\sum F_{sys} = m_{sys} \cdot a_{sys}$

$80N - 90\cos 55 = (9+8) \cdot a_{sys} \rightarrow a_{sys} = \frac{80N - 90\cos 55}{17}$

$\boxed{a_{sys} = 1.67 \frac{m}{s^2}}$

11) Find the tension in the string once the system is released.

why isn't T here the same as FF calc? $T - 90\cos 55 = 0$?

$\sum F_{load} = m_{load} \cdot a_{load}$

$-T + 80N = 8(1.67)$

$T = 80N - 13.36$

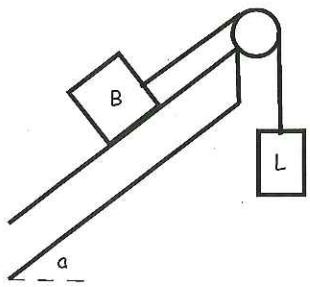
$\boxed{T = 66.64N}$

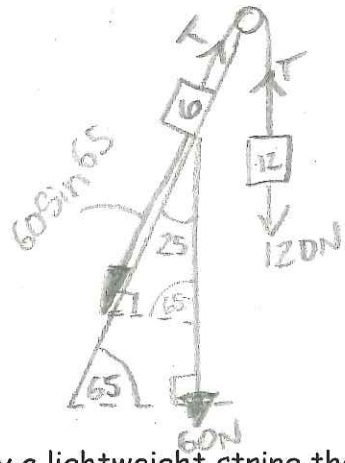
12) What is the tension in the string before the system is released?

$\sum F_y = 0$

$T - 80N = 0$

$\boxed{T = 80N}$





A 12 kg load, and a 6 kg block, are attached by a lightweight string that passes over a frictionless pulley of negligible mass. The block lies on a frictionless surface that is inclined at an angle of 65 degrees above the horizontal.

13) Find the acceleration of the load once the system is released.

$\sum F_{sys} = m_{sys} \cdot a_{sys} \rightarrow 120N + (-60\sin 65) = (6+12)\, a_{sys}$

$a_{sys} = \dfrac{120N - 60\sin 65}{18} \rightarrow \boxed{a_{sys} = 3.65 \frac{m}{s^2}}$

14) Find the tension in the string once the system is released.

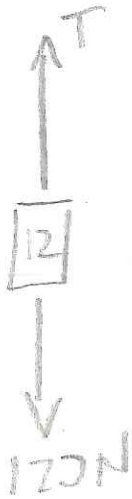
$\sum F_{Load} = m_{Load} \cdot a_{Load}$

$-T + 120N = 12(3.65)$

$T = 120N - 43.8$

$\boxed{T = 76.2}$

15) What is the tension in the string before the system is released?

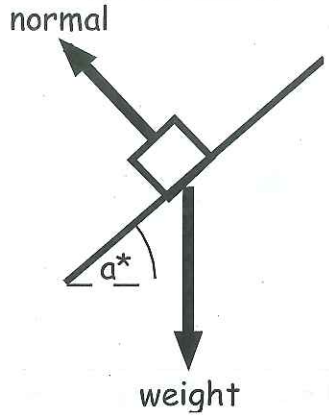


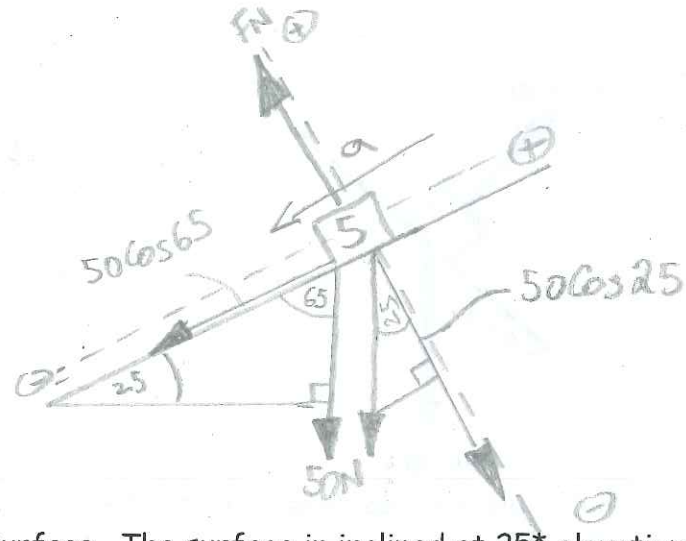
$\sum F_y = 0$ because there is no acceleration.

$T + (-120N) = 0$

$\boxed{T = 120N}$

Dynamics (3)





A 5kg block slides down a frictionless surface. The surface in inclined at 25* elevation above the horizontal.

16) What is the acceleration of the block down the slope of the surface?

$$\sum F_{sys} = m_{sys} \cdot a_{sys}$$

$$-50\cos 65 = 5 a_{sys}$$

$$a_{sys} = \frac{-50\cos 65}{5}$$

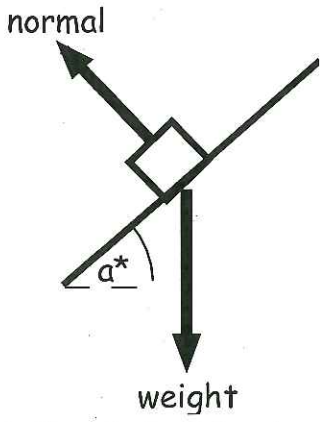
$$\boxed{a_{sys} = -4.23 \frac{m}{s^2}}$$

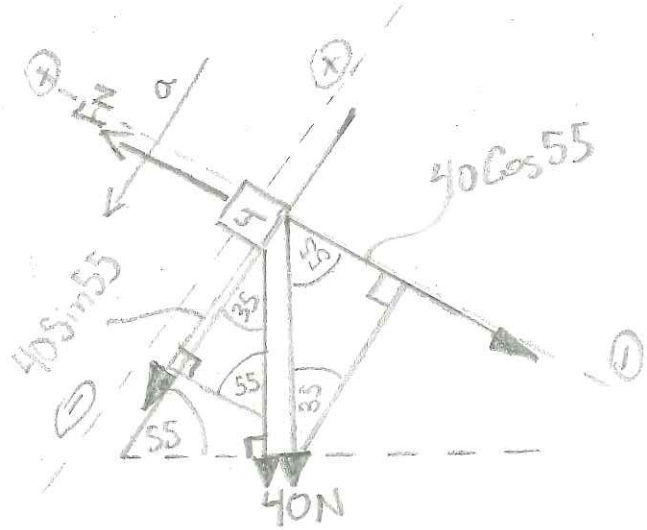
17) What is the normal force?

$$\sum F = 0 \therefore \quad F_n + (-50\cos 25) = 0$$

$$F_n = 50\cos 25$$

$$\boxed{F_n = 45.32 N}$$





A 4kg block slides down a frictionless surface. The surface in inclined at 55* elevation above the horizontal.

18) What is the acceleration of the block down the slope of the surface?

$$\sum F_{sys} = m_{sys} \cdot a_{sys}$$

$$-40\sin 55 = 4 \cdot a_{sys}$$

$$a_{sys} = \frac{-40\sin 55}{4}$$

$$a_{sys} = -10\sin 55$$

$$\boxed{a_{sys} = -8.19\ \frac{m}{s^2}}$$

19) What is the normal force?

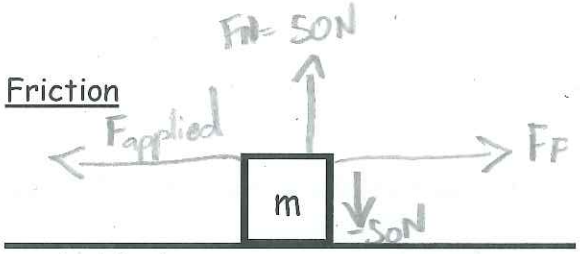
? $\longrightarrow$ $\sum F_y = 0$ $\longrightarrow$ Why not $F_N + (-40\cos 55) + (-40N) = 0$?

$$F_N + (-40\cos 55) = 0$$

$$F_N = 40\cos 55$$

$$\boxed{F_N = 22.94N}$$

Friction



A 5kg block rests on a rough surface. The coefficient of static friction is 0.7 and the coefficient of kinetic friction is 0.5.

20) What is the maximum force of static friction that the system can exhibit?

$\mu_s = 0.7$

$\mu_K = 0.5$

$F_s = \mu_s F_N$

$F_s = 0.7(50N)$

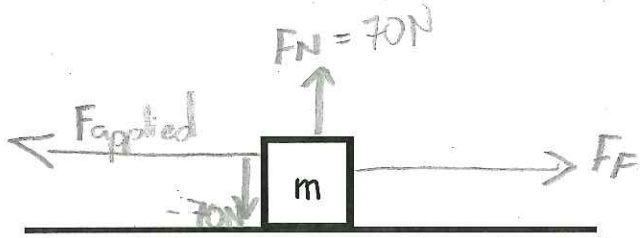
$F_s = 35N$

21) What is the force of kinetic friction that the system exhibits?

$F_{F_K} = \mu_K \cdot F_N$

$F_{F_K} = 0.5(50N)$

$\boxed{F_{F_K} = 25N}$



A 7kg block rests on a rough surface. The coefficient of static friction is 0.9 and the coefficient of kinetic friction is 0.4.

22) What is the maximum force of static friction that the system can exhibit?

$\mu_s = 0.9$

$\mu_k = 0.4$

$F_{F_s} = \mu_s \cdot F_N$

$F_{F_s} = 0.9(70N)$

$F_{F_s} = 63N$

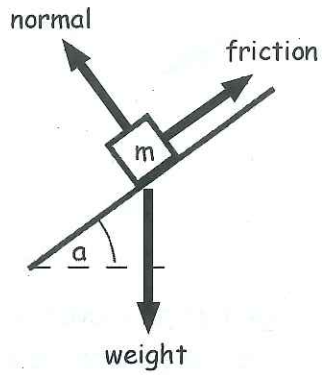
23) What is the force of kinetic friction that the system exhibits?

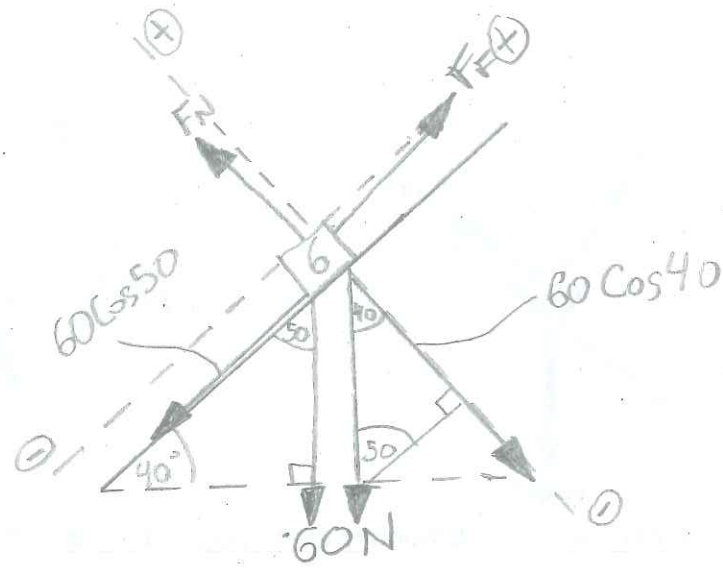
$F_{F_k} = \mu_k (F_N)$

$F_{F_k} = 0.4(70N)$

$F_{F_k} = 28N$

Statics with Friction





A 6kg block is stationary on a rough surface. The surface is sloped at an elevation of 40 degrees above the horizontal. The block is on the point of slipping, (any increase in slope causes it to slip).

24) What is the normal force?

$$\sum F_{\perp} = 0$$

$$F_N + (-60\cos 40) = 0$$

$$F_N = 60\cos 40$$

$$\boxed{F_N = 45.96\,N}$$

25) What is the frictional force?

$$\sum F_{\perp F_N} = 0$$

$$F_F - 60\cos 50 = 0$$

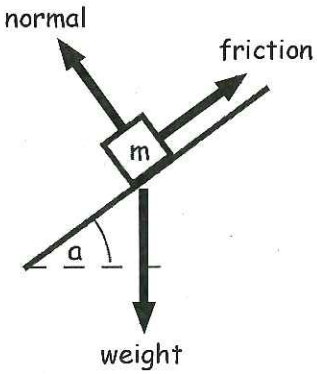
$$F_F = 60\cos 50$$

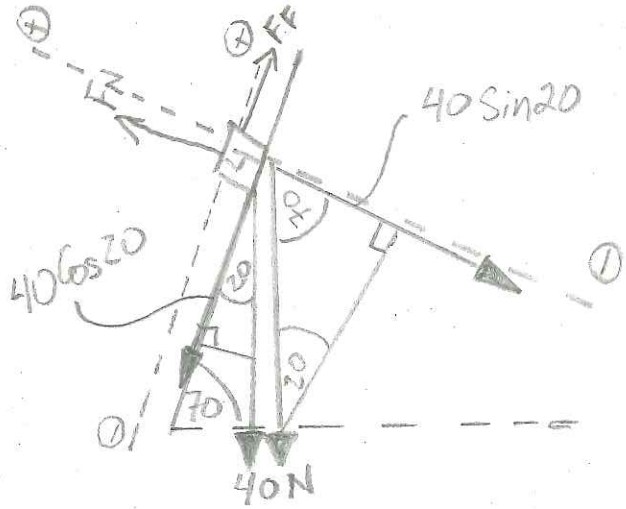
$$\boxed{F_F = 38.57\,N}$$

26) What is the coefficient of static friction?

$$F_{F_s} = \mu_s F_N \longrightarrow \mu_s = \frac{F_{F_s}}{F_N}$$

$$\mu_s = \frac{38.57\,N}{45.96\,N} \longrightarrow \boxed{\mu_s = 0.839}$$





A 4kg block is stationary on a rough surface. The surface is sloped at an elevation of 70 degrees above the horizontal. The block is on the point of slipping, (any increase in slope causes it to slip).

27) What is the normal force? $\sum F_{\perp FF} = 0$

$F_N + (-40\sin 20) = 0$

$F_N = 40\sin 20$

$\boxed{F_N = 13.68N}$

28) What is the frictional force? $\sum F_{\perp FN} = 0$

$F_F + (-40\cos 20) = 0$

$F_F = 40\cos 20$

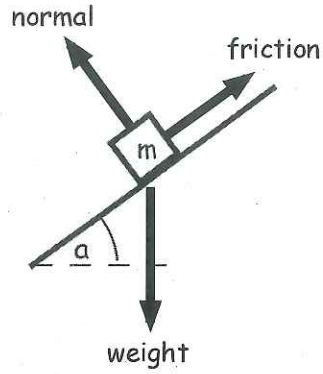
$\boxed{F_F = 37.59N}$

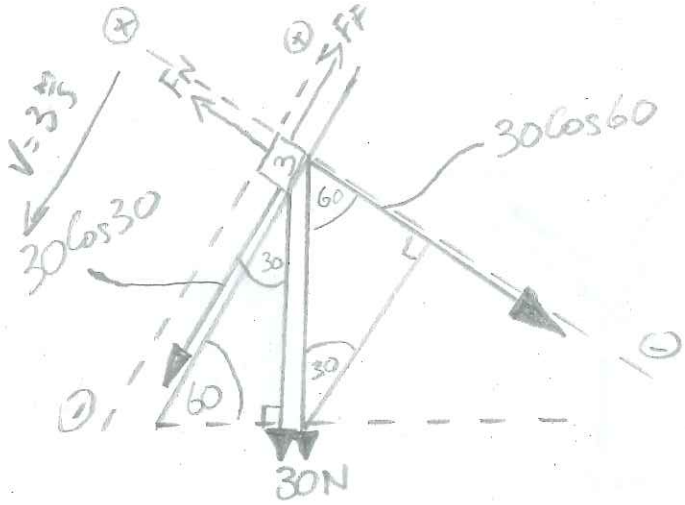
29) What is the coefficient of static friction?

$F_{F_s} = \mu_s F_N$

$\mu_s = \frac{F_{F_s}}{F_N}$

$\mu_s = \frac{37.59N}{13.68N}$ → $\boxed{\mu_s = 2.75}$





A 3kg block slides down a rough surface at a constant 3m/s. The surface is sloped at an elevation of 60 degrees above the horizontal.

30) What is the normal force?

$F_N - 30\cos 60 = 0$

$F_N = 30\cos 60$

$\boxed{F_N = 15N}$

31) What is the frictional force?

$F_F - 30\cos 30 = 0$

$F_F = 30\cos 30$

$\boxed{F_F = 25.9N}$

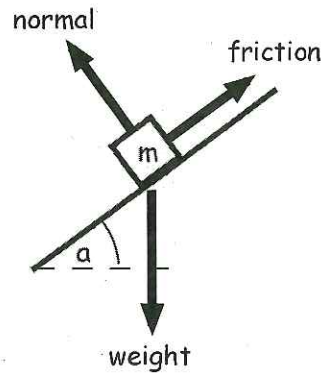
32) What is the coefficient of kinetic friction?

$F_{FK} = \mu_K F_N$

$\mu_K = \frac{F_{FK}}{F_N}$

$\mu_K = \frac{25.9N}{15N}$

$\boxed{\mu_K = 1.73}$



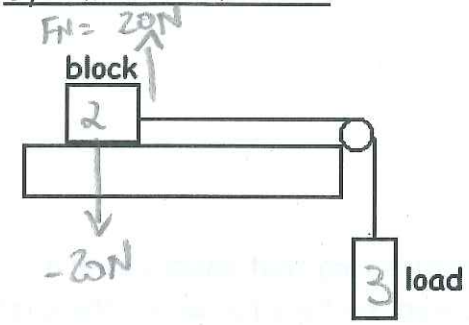
A 6kg block slides down a rough surface at a constant 8m/s. The surface is sloped at an elevation of 40 degrees above the horizontal.

33) What is the normal force?

34) What is the frictional force?

35) What is the coefficient of kinetic friction?

Dynamics with Friction



A 3 kg load, and a 2 kg block, are attached by a lightweight string that passes over a frictionless pulley of negligible mass. The block lies on a level surface for which the coefficient of kinetic friction is 0.4.

36) What force of kinetic friction is exhibited while the block is in motion?

$F_{FK} = \mu_K F_N$

$F_{F_K} = 0.4(20N)$

$\boxed{F_{F_K} = 8N}$

37) Find the acceleration of the load once the system is released.

$\Sigma F = m \cdot a$

$-T + 30 = 3 \cdot a \longrightarrow -T = -30 + 3(4.4)$

$T = 30 - 13.2$

$\boxed{T = 16.8N}$

$\Sigma F_{sys} = m_{sys} \cdot a_{sys}$

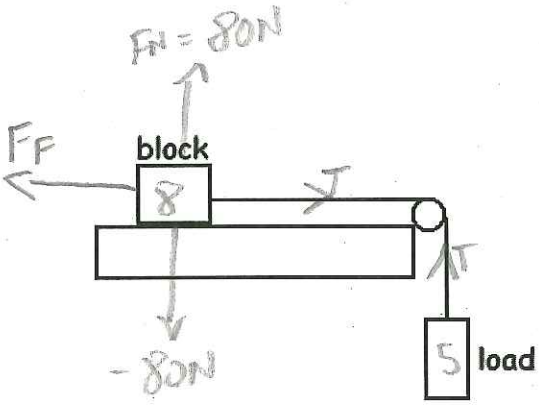
$30 - 8 = (2+3)a$

$a = 4.4 \frac{m}{s^2}$

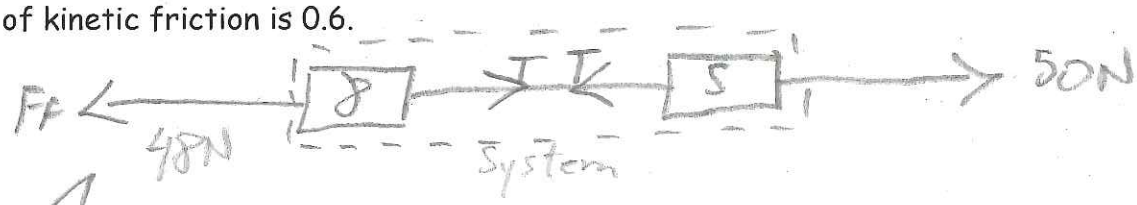
38) Find the tension in the string once the system is released.

$T = 30 - 3(4.4)$

$\boxed{T = 16.8N}$



A 5 kg load, and an 8 kg block, are attached by a lightweight string that passes over a frictionless pulley of negligible mass. The block lies on a level surface for which the coefficient of kinetic friction is 0.6.



39) What force of kinetic friction is exhibited while the block is in motion?

$F_{F_K} = \mu_K F_N$

$F_{F_K} = 0.6(80N)$

$\boxed{F_F = 48N}$

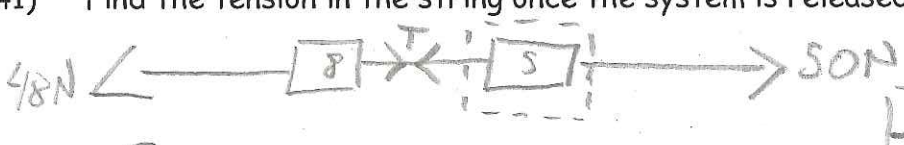
40) Find the acceleration of the load once the system is released.

$\sum F_{sys} = m_{sys} \cdot a_{sys}$

$50N - 48N = (8+5) \cdot a$

$\frac{2}{13} = a_{sys} \longrightarrow \boxed{a_{sys} = 0.15 \frac{m}{s^2}}$

41) Find the tension in the string once the system is released.



$\sum F_{load} = m_{load} \cdot a_{load}$

$-T + 50N = 5(.15)$

$T = 50N - .75$

$\boxed{T = 49.25N}$

Chapter 5 Answers

1) 28.2 N
2) 10.3 N
3) 24.6 N
4) 17.2 N
5) 10.3 N
6) 28.2 N
7) 1.2 m/s^2
8) 53.1 N
9) 60.0 N
10) 1.7 m/s^2
11) 66.6 N
12) 80.0 N
13) 3.6 m/s^2
14) 76.2 N
15) 120.0 N
16) 4.2 m/s^2
17) 45.3 N
18) 8.2 m/s^2
19) 22.9 N
20) 35.0 N
21) 25.0 N
22) 63.0 N
23) 28.0 N
24) 46.0 N
25) 38.6 N
26) 0.84
27) 13.7 N
28) 37.6 N
29) 2.74 (unrealistically big)
30) 15.0
31) 26.0 N
32) 1.73
33) 46.0 N
34) 38.6 N
35) 0.84
36) 8.0 N
37) 4.4 m/s^2
38) 16.8 N
39) 48.0 N
40) 0.15 m/s^2
41) 49.2

2048 Momentum - Collisions - Impulse Homework

Momentum

1) A 2kg block has a velocity of 5m/s to the right. What is its momentum? (10kgm/s to the right)

$p = mv$

$p = (2)(+5)$

$p = \boxed{+10\ kgm/s}$

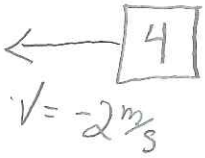
2) A 3kg block has a velocity of 2m/s to the left. What is its momentum? (6kgm/s to the left)

$\vec{p} = (m)(\vec{v})$

$\vec{p} = (3kg)(-2m/s)$

$\boxed{\vec{p} = -6\ \frac{kgm}{s}}$

3) A 4kg block has a velocity of -2m/s. What is its momentum? (-8kgm/s to the left)



$\vec{p} = (m)(\vec{v})$

$\vec{p} = (4kg)(-2\frac{m}{s})$

$\boxed{\vec{p} = -8\ \frac{kgm}{s}}$

4) A 4 kg block has a velocity of (3i+2j-3k)m/s. What is its vector momentum?

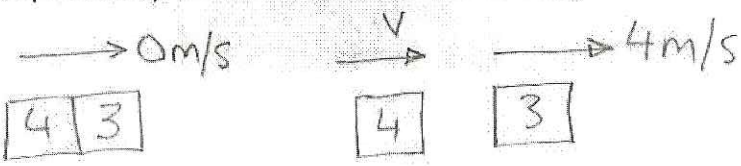
$\vec{p} = m\vec{v}$

$\vec{p} = (4)(3+2-3)$

$\vec{p} = (12\hat{i} + 8\hat{j} - 12\hat{k})\ \frac{kgm}{s}$

Conservation of Linear Momentum

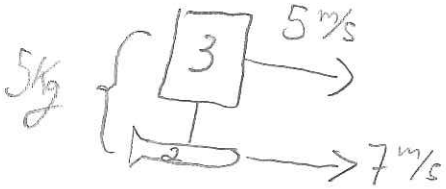
5) A 4kg astronaut is at rest holding a 3kg block during a spacewalk. She pushes the block to the right giving it a speed of 4m/s. What is her velocity after the throw? (3 m/s to the left) (just like perfectly inelastic collision in reverse)



perfectly inelastic

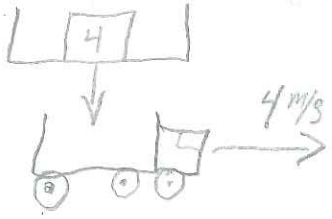
$$P_i = P_f$$
$$(m_1+m_2)V_i = m_1V_{1f} + m_2V_{2f}$$
$$(4+3)(0) = (4)(V) + (3)(+4)$$
$$0 = 4V + 12$$
$$4V = -12$$
$$V = \boxed{-3\,m/s}$$

6) A 3kg spaceship is coasting at 5m/s to the right (relative to space) while carrying a 2kg phpton torpedo. The total mass of spaceship and torpedo is 5kg. The spaceship fires the torpedo to the right giving it a velocity of 7m/s (relative to space). What is the velocity of the space ship (relative to space) after firing its torpedo? (3.7 m/s to the right)



$$P_i = P_f$$
$$m_i\vec{V}_i = m_f\vec{V}_f$$
$$m_1\vec{V}_{1f} + m_2\vec{V}_{2f} = (m_1+m_2)\vec{V}$$
$$(3)(V_{1f}) + (2)(7) = (3+2)(5)$$
$$3V_{1f} + 14 = (5)(5)$$
$$3V_{1f} = 25 - 14$$
$$V_{1f} = \frac{11}{3}$$
$$\boxed{V_{1f} = 3.66\,m/s}$$

7) A 2kg empty coal truck coasts horizontally at 4m/s to the right. It passes under a silo that lets 4kg of coal drop vertically into the truck. What is the horizontal velocity of the truck after this process? (1.3 m/s to the right)



$m_T \cdot \vec{V}_T + m_c \cdot V_c$

$2Kg \cdot 4\frac{m}{s} + 4Kg \cdot 0\frac{m}{s}$

$\vec{P}_i = 8 Kg\,m/s$

$P_i = m_{TC} \cdot V_{TC}$

$8 Kg\,m/s = (2+4) \cdot V_{TC}$

$8 Kg\,m/s = 6 Kg \cdot V_{TC}$

$V_{TC} = \frac{8 Kg\,m/s}{6 Kg}$

$\boxed{V_{TC} = 1.3\ m/s}$

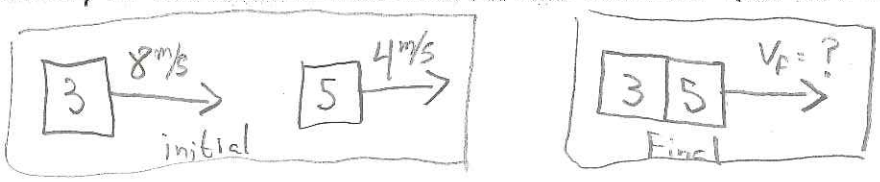
Perfectly Inelastic Collisions

8) A 2kg block traveling with a velocity of 5m/s to the right collides with a 4kg block traveling at 3 m/s to the left. The two blocks stick together after the collision. What is the velocity of the combined block after the collision? (0.3m/s to the left)

$$P_i = P_f$$
$$m_1 v_{1_i} + m_2 v_{2_i} = (m_1 + m_2) v_f$$
$$(2)(+5) + (4)(-3) = (2+4)(v_f)$$
$$(+10) + (-12) = 6 v_f$$
$$6 v_f = -2$$
$$v_f = \boxed{-\tfrac{1}{3}\ m/s}$$

so, to the left

9) A 3kg block traveling with a velocity of 8m/s to the right collides with a 5kg block traveling at 4 m/s to the right. The two blocks stick together after the collision. What is the velocity of the combined block after the collision? (5.5 m/s to the right)



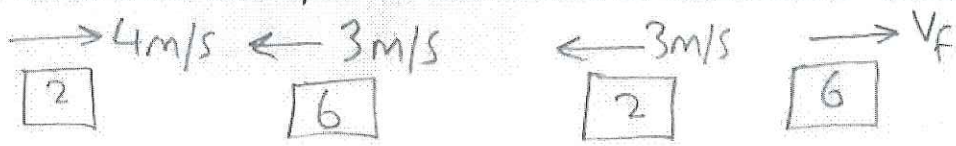
$$\vec{p}_i = m_i \vec{v}_1 + m_2 \vec{v}_2$$
$$\vec{p}_i = (3)(8) + (5)(4)$$
$$\vec{p}_i = 24\,kg\,m/s + 20\,kg\,m/s$$
$$\vec{p}_i = 44\,kg\,m/s$$

$$\vec{p}_i = \vec{p}_f$$
$$\vec{p}_i = m_f \cdot \vec{v}_f$$
$$44\,kg\,m/s = (3+5) \cdot \vec{v}_f$$
$$44\,kg\,m/s = 8\,kg \cdot \vec{v}_f$$
$$v_f = \frac{44\,kg\,m/s}{8\,kg}$$
$$\boxed{v_f = 5.5\,m/s}$$

Right

Inelastic Collisions

10) A red 2kg block traveling with a velocity of 4m/s to the right collides with a blue 6kg block traveling at 3 m/s to the left. After the collision the red block has a velocity of 3m/s to the left. What is the velocity of the blue block after the collision? (0.7m/s to the left)



$$P_i = P_f$$

$$m_1 V_{1i} + m_2 V_{2i} = m_1 V_{1f} + m_2 V_{2f}$$

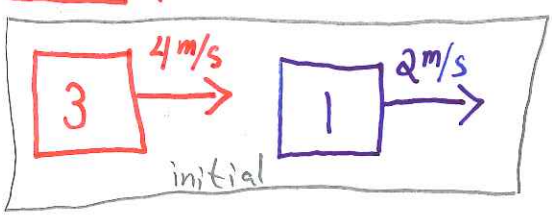
$$(2)(+4) + (6)(-3) = (2)(-3) + (6)(V)$$

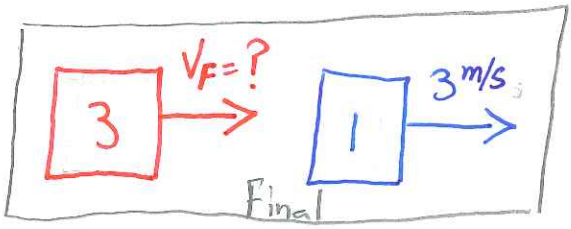
$$(+8) + (-18) = (-6) + 6V$$

$$-4 = +6V$$

$$V = \boxed{-\frac{2}{3}\ m/s}$$ so, to the left

11) A red 3kg block traveling with a velocity of 4m/s to the right collides with a blue 1kg block traveling at 2 m/s to the right. After the collision the blue block has a velocity of 3m/s to the right. What is the velocity of the red block after the collision? (3.7 m/s to the left) ?





$$\vec{p}_i = m_1 \cdot \vec{V}_1 + m_2 \cdot \vec{V}_2$$

$$\vec{p}_i = (3)(4) + (1)(2)$$

$$\vec{p}_i = 12 + 2$$

$$\vec{p}_i = 14\ kg\ m/s$$

$$\vec{p}_i = \vec{p}_f$$

$$\vec{p}_i = m_{1F} \cdot \vec{V}_{1F} + m_{2F} \cdot \vec{V}_{2F}$$

$$14 = (3)V_{1F} + (1)(3)$$

$$14 = 3V_{1F} + 3$$

$$3V_{1F} = 11$$

$$V_{1F} = \frac{11}{3}$$

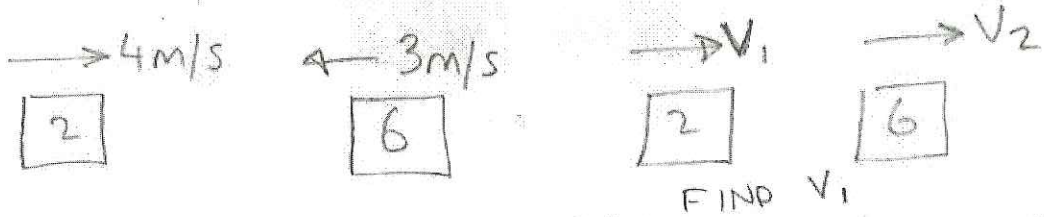
$$\boxed{V_{1F} = 3.7\ m/s}$$ Right

?

Elastic Collisions

A red 2kg block traveling with a velocity of 4m/s to the right collides with a blue 6kg block traveling at 3 m/s to the left. The collision is elastic.

12) What is the velocity of the red 2kg truck after the collision? (6.5m/s to the left)



$$P_i = P_f$$

$$m_1 V_{1_i} + m_2 V_{2_i} = m_1 V_{2_f} + m_2 V_{2_f}$$

$$(2)(+4) + (6)(-3) = (2)(V_1) + (6)(V_2)$$

$$(+8) + (-18) = 2V_1 + 6V_2$$

$$-10 = 2V_1 + 6V_2 \quad (1)$$

$$V_{1_i} - V_{2_i} = -(V_{1_f} - V_{2_f})$$

$$(+4) - (-3) = -(V_1 - V_2)$$

$$+7 = V_2 - V_1 \quad (2)$$

Find V_1, so, Isolate V_2 in (2)

$$V_2 = 7 + V_1$$

substitute in (1)

$$-10 = 2V_1 + 6V_2 = 2V_1 + 6(7 + V_1)$$

$$-10 = 2V_1 + 42 + 6V_1$$

$$-52 = 8V_1$$

$$V_1 = \boxed{-6.5\,m/s}$$ so, to the left.

OR $V_{1i} - V_{2i} = -(V_{1F} - V_{2F})$

$4 - 3 = -([-5 - 3V_{2F}] - V_{2F})$

$1 = 5 + 3V_{2F} + V_{2F}$

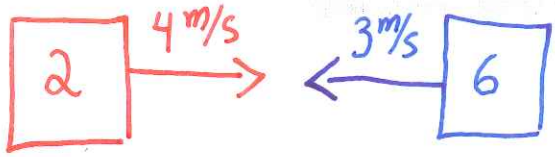
$1 = 5 + 4V_{2F}$

$4V_{2F} = -4$

$V_{2F} = -1$

A red 2kg block traveling with a velocity of 4m/s to the right collides with a blue 6kg block traveling at 3 m/s to the left. The collision is elastic.

13) What is the velocity of the blue 6kg block after collision? (0.5m/s to the right) ?



$p_i = m_{1i} \cdot V_{1i} + m_{2i} \cdot V_{2i}$

$p_i = (2)(4) + (6)(-3)$

$p_i = 8 - 18$

$p_i = -10 \text{ kgm/s}$

$p_i = p_F$

$p_i = m_{1F} \cdot V_{1F} + m_{2F} \cdot V_{2F}$

$-10 \text{ kgm/s} = 2V_{1F} + 6V_{2F}$

$KE_{1i} + KE_{2i} = KE_{1F} + KE_{2F}$

$\cancel{\tfrac{1}{2}} m_{1i} V_{1i}^2 + \cancel{\tfrac{1}{2}} m_{2i} V_{2i}^2 = \cancel{\tfrac{1}{2}} m_{1F} \cdot V_{1F}^2 + \cancel{\tfrac{1}{2}} m_{2F} \cdot V_{2F}^2$

$m_{1i} \cdot V_{1i}^2 + m_{2i} V_{2i}^2 = m_{1F} \cdot V_{1F}^2 + m_{2F} \cdot V_{2F}^2$

$(2)(4)^2 + (6)(-3)^2 = (2)V_{1F}^2 + 6V_{2F}^2$

$32 + 54 = 2V_{1F}^2 + 6V_{2F}^2$

$86 = 2V_{1F}^2 + 6V_{2F}^2$

{Don't want to deal w/ sqr root so I'll work w/ other eq.}

$-10 \text{ kgm/s} = 2V_{1F} + 6V_{2F}$

$2V_{1F} = -10 - 6V_{2F}$

$V_{1F} = \dfrac{-10 - 6V_{2F}}{2}$

$V_{1F} = -5 - 3V_{2F}$

Plug into KE eq.

$86 = 2V_{1F}^2 + 6V_{2F}^2$

$86 = 2(-5 - 3V_{2F})^2 + 6V_{2F}^2$

$86 = 2(25 + 15V_{2F} + 9V_{2F}^2) + 6V_{2F}^2$

$86 = 50 + 30V_{2F} + 18V_{2F}^2 + 6V_{2F}^2$

$24V_{2F}^2 + 30V_{2F} - 36 = 0$

$6(4V_{2F} - 3)(V_{2F} + 2) = 0$

$4V_{2F} - 3 = 0$

$4V_{2F} = 3$

$V_{2F} = +\dfrac{3}{4} \text{ m/s}$

$\boxed{V_{2F} = 0.75 \text{ m/s}}$

Right

OR $V_{2F} + 2 = 0$

$V_{2F} = -2 \text{ m/s}$

$I = F\Delta T$ OR $I = \Delta P = (m \cdot V)_F - (m \cdot V)_i$

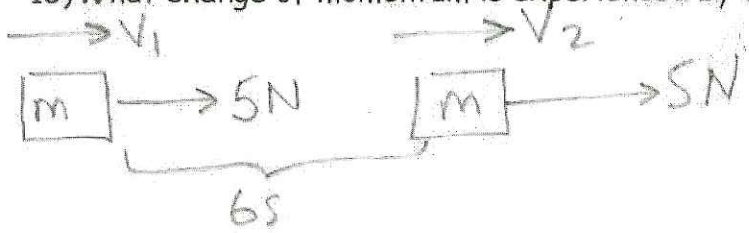
Impulse / Momentum

A 5N force is applied to a block for 6s.

14) What impulse is applied by the force? (30Ns)

$I \equiv (F)(\Delta t) = (+5)(6) = \boxed{+30\ Ns}$

15) What change of momentum is experienced by the block? (30kgm/s)



$I = \Delta P$

$30 Ns = \Delta P$

$\Delta P = (5N)(6s)$

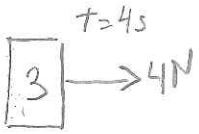
$\boxed{\Delta P = 30\ kg\ m/s}$

$\Delta p = Imp$

$\Delta p = (F)(\Delta t) = (+5)(6) = \boxed{+30\ kg\ m/s}$

A 4N force is applied to a 3kg block for 7s.

16) What impulse is applied by the force? (28Ns)

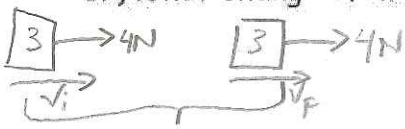


$I = F \cdot \Delta T$

$I = (4N)(7s)$

$\boxed{I = 28 Ns}$

17) What change of momentum is experienced by the block? (28kgm/s)



$\Delta P = I$

$28 Ns = \Delta P$

$\Delta P = 28\ kg\ m/s$

18) What velocity would be attained by the block at the end of the 7s journey? (9.3m/s)

$P = m \cdot V$

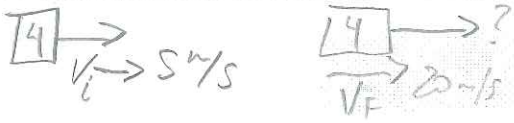
$28\ kg\ m/s = 3\ kg \cdot V$

$V = \frac{28}{3} \frac{m}{s}$

$\boxed{V = 9.33\ m/s}$

A 4kg block, with an initial velocity of 5m/s, is pushed by a force for 6s. At the end of 6s the block has a velocity of 20m/s.

19) What is the Impulse produced by the force? (60Ns)



$I = \Delta P = (m \cdot v)_F - (m \cdot v)_i$

$I = 4(20) - 4(5)$

$I = 80 - 20$

$I = 60$

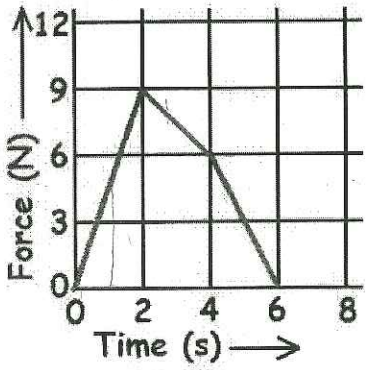
20) What is the average applied force during this journey? (10N)

$I = F\Delta T$

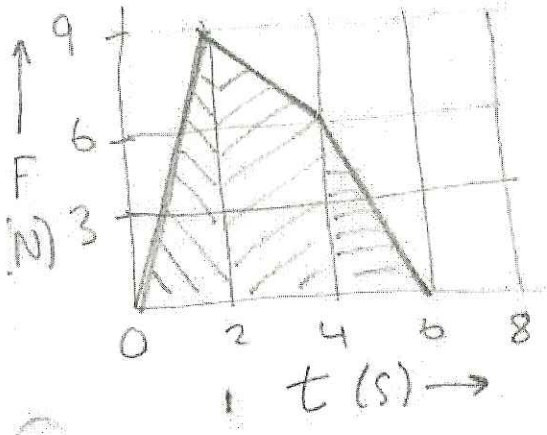
$F = \frac{I}{\Delta T}$

$F = \frac{60 Ns}{6s}$

$F = 10N$



21) What is the impulse caused by this varying force between t=0s and t=6s? (30Ns)



$I = (F)(\Delta t) = \int F(t)\,dt =$ area under graph

$I = \frac{1}{2}(2)(9) + \frac{1}{2}(9+6)(2) + \frac{1}{2}(2)(6)$

$I = 9 + 15 + 6$

$I = \boxed{30\,Ns}$

22) What is the impulse caused by this varying force between t=1s and t=4s? (21.75Ns)

$I = (F)(\Delta T) =$ Area under the graph

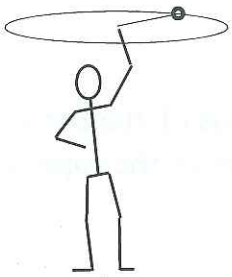
$I = \frac{1}{2}(9+4.5)(1) + \frac{1}{2}(9+6)(2)$

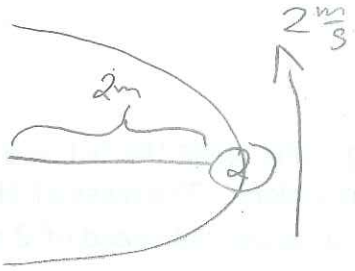
$I = 6.75 + 15$

$\boxed{I = 21.75\,Ns}$

2048 Circular Motion Homework

Newton's second law applied to uniform circular motion (1) Horizontal Soap on a Rope





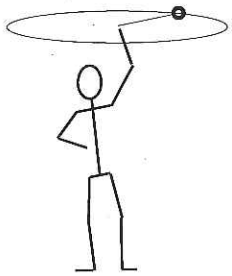
A student has a 'Ball on a String'. She spins the ball in a circular path. The radius of the path is 2m. The circle is in the horizontal plane. The mass of the soap is 2kg. The mass of the rope is negligible. She spins the ball at a tangential speed of 2 m/s.

1) What is the tension in the string?

Force is provided by tension in the string

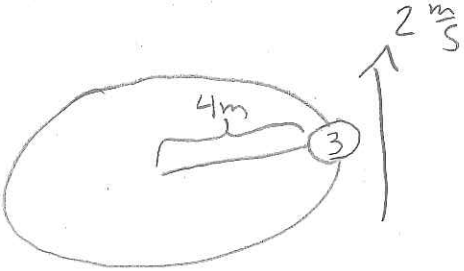
$$F_{centripetal} = m \cdot a_{centripetal} = m \cdot \frac{v^2}{r}$$

$$F_{cent} = 2kg \cdot \frac{\left(2\,\frac{m}{s}\right)^2}{2m} = 4\,\frac{kg \cdot m}{s^2} = \boxed{4N}$$



A student has a 'Ball on a String'. She spins the ball in a circular path. The radius of the path is 4m. The circle is in the horizontal plane. The mass of the soap is 3kg. The mass of the rope is negligible. She spins the ball at a tangential speed of 2 m/s.

2) What is the tension in the string?



Tension = Centripetal force produced by rotating this ball on a string

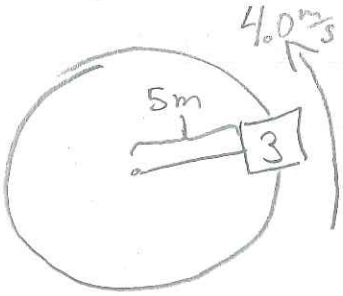
$$F_{cent} = m \cdot a_{cent} = \frac{m \cdot v^2}{r}$$

$$F_{cent} = \frac{3\,kg \cdot (2\,m/s)^2}{4\,m} = \boxed{3\,N}$$

Newton's second law applied to uniform circular motion (2) Car on a Track

A 3.0 kg car travels at 4.0 m/s around a level circular racetrack of radius 5.0 m.

3) What is the centripetal acceleration as a result of this movement?



$$a_{cent} = \frac{v^2}{r} = \frac{(4\,m/s)^2}{5\,m}$$

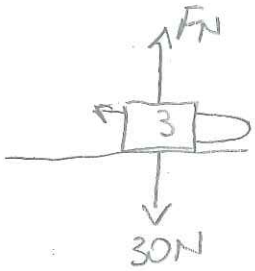
$$= \boxed{3.2\ \frac{m}{s^2}}$$

4) What force provides this centripetal acceleration?

Force of the tires on track & friction of track on tires. $F_{cent} = m \cdot a_{cent} = \frac{mv^2}{r} = \frac{3 \cdot (4)^2}{5} = \boxed{9.6\,N}$

5) What is the coefficient of friction between the tires and the track?

$$F_{FK} = \mu_K F_N$$



$$F_{FK} = F_{cent} = 9.6\,N$$

$$F_n - 30\,N = 0$$

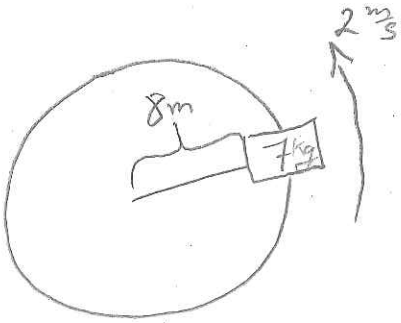
$$F_n = 30\,N$$

$$F_{FK} = \mu_K F_N$$

$$\mu_K = \frac{F_{FK}}{F_N} = \frac{9.6\,N}{30\,N} = \boxed{.32}$$

A 7.0 kg car travels at 2.0 m/s around a level circular racetrack of radius 8.0 m.

6) What is the centripetal acceleration as a result of this movement?

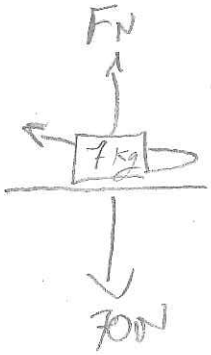


$$a_{cent} = \frac{v^2}{r} = \frac{(2\,\frac{m}{s})^2}{8\,m} = \boxed{0.5\,\frac{m}{s^2}}$$

7) What is the coefficient of friction between the tires and the track?

$$F_F = F_{cent} = m \cdot a_{cent} = \frac{m v^2}{r}$$

$$F_{F_K} = \frac{7 \cdot (2\,\frac{m}{s})^2}{8\,m} = 3.5\,N$$



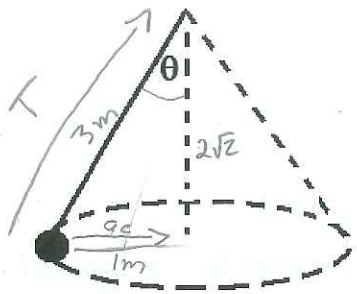
$$F_N - 70N = 0$$

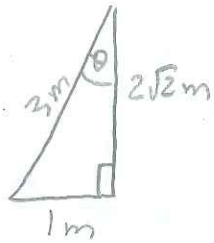
$$F_N = 70N$$

$$F_{F_K} = \mu_K F_N = \mu_K = \frac{F_{F_K}}{F_N}$$

$$\mu_K = \frac{3.5N}{70N} = \boxed{0.05}$$

Newton's second law applied to uniform circular motion (3) Conical Pendulum





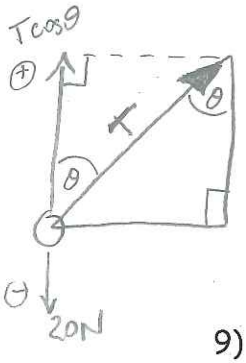
$\sin\theta = \frac{1}{3}$

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

$\theta = 19.5°$

A 2kg ball is suspended from a 3m long string. The ball revolves at a constant tangential speed in a horizontal circle of 1m radius, forming a conical pendulum.

8) What is the tension in the string?



$\text{Tension} = \sum F_V = 0$ Perpendicular to a_c that we don't know

$T\cos\theta + (-20) = 0$

$T\cos(19.5) = 20\text{ N}$

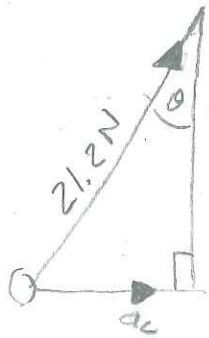
$T = \frac{20\text{N}}{\cos(19.5)} = \boxed{T = 21.2\text{N}}$

9) What is the centripetal acceleration?

$a_c = \frac{V^2}{r} = V = ?$

So use $\sum F = m \cdot a_c$

$a_c = \frac{\sum F}{m} = \frac{\text{Tension}}{m} = \frac{21.2\sin(19.5)}{2\text{kg}}$



$\boxed{a_c = 3.5\ \frac{m}{s^2}}$

10) What is the tangential velocity of the bob)

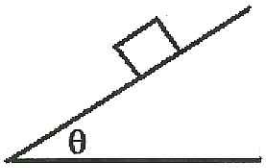
$\sum F_{cent} = m \cdot a_{cent} = \frac{mv^2}{r}$ or $a_c = \frac{v^2}{r}$

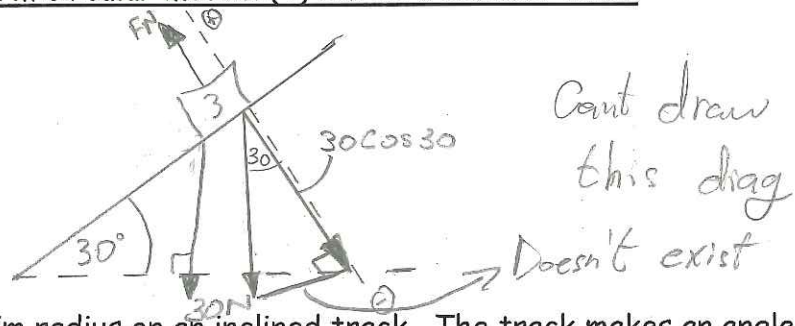
$\frac{\sum F \cdot r}{m} = v^2$

$V = \sqrt{a_c \cdot r} = \sqrt{3.5(1)} =$

$V = \sqrt{\frac{\sum F \cdot r}{m}} = \sqrt{\frac{21.2\sin(19.5)\cdot(1)}{2}} = \boxed{1.88\ \frac{m}{s}}$

Newton's second law applied to uniform circular motion (4) Car on a Banked Track





Cant draw this diag

A 3kg car drives around a circle of 7m radius on an inclined track. The track makes an angle of 30° with the horizontal. The car is driven at a speed so that no centripetal frictional force is required from the tires?

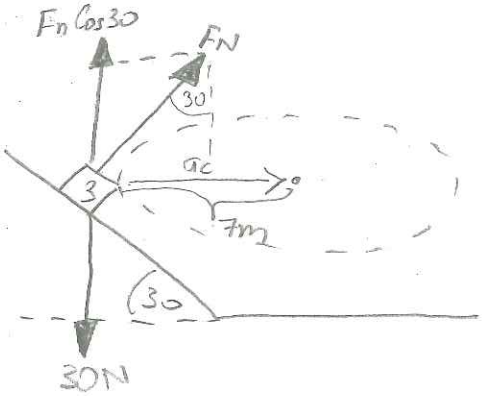
11) What is the normal force acting on the car?

$$\sum F = 0$$

$$F_N \cos 30 - 30N = 0$$

$$F_N = \frac{30}{\cos 30} = \boxed{34.64N}$$

12) What is the centripetal force provided by the normal force?



F_{cent} = horizontal component of F_N

$$F_{cent} = F_N \sin 30 = 34.64 \sin 30$$

$$\boxed{F_{cent} = 17.32N}$$

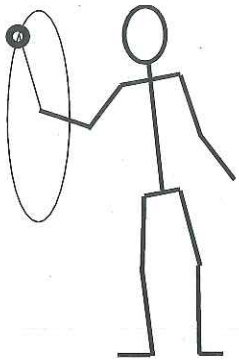
13) What is the speed of the car?

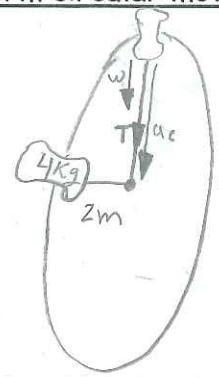
$$F_{cent} = \frac{m \cdot v^2}{r}$$

$$v = \sqrt{\frac{F_{cent} \cdot r}{m}} = \sqrt{\frac{17.32 \cdot 7}{3}} =$$

$$\boxed{v = 6.36 \, m/s}$$

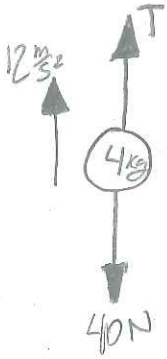
Newton's second law applied to uniform circular motion (5) Vertical Soap on a Rope





A student has a 'Soap on a Rope'. She spins the soap in a circular path. The radius of the path is 2m. The circle is in the vertical plane. The mass of the soap is 4kg. The mass of the rope is negligible. She spins the soap at a speed that requires a centripetal acceleration of 12 m/s^2.

14) What is the tension in the rope when the soap is directly below her hand?



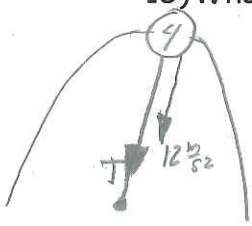
Find T using $\sum F_v = m a_v = m a_c$

$(+T) + (-40) = (4)(+12)$

$T = 48 + 40$

$\boxed{T = 88N}$

15) What is the tension in the rope when the soap is directly above her hand?



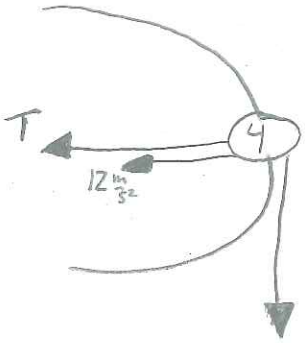
$\sum F_v = m \cdot a_v = m a_c$

$(-T) + (-40) = 4(-12)$

$-T = 40 - 48$

$\boxed{T = 8N}$

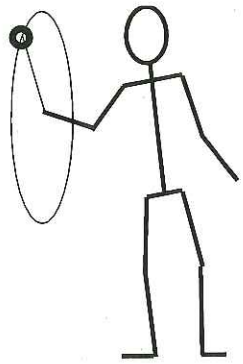
16) What is the tension in the rope when the soap is level with her hand?

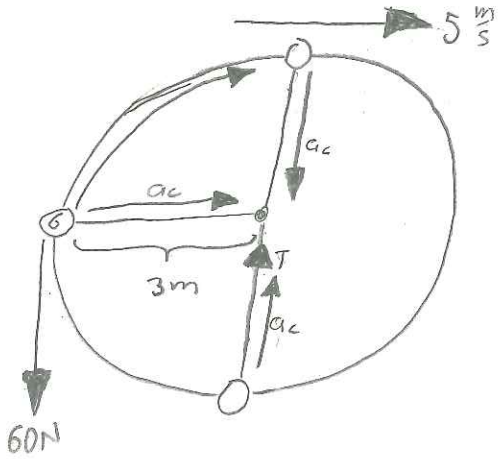


$\sum F_h = m \cdot a_h = m \cdot a_c$

$(+T) = (4)(+12)$

$\boxed{T = 48N}$





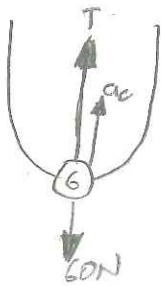
A student has a 'Soap on a Rope'. She spins the soap in a circular path. The radius of the path is 3m. The circle is in the vertical plane. The mass of the soap is 6kg. The mass of the rope is negligible. She spins the soap at a tangential speed of 5m/s.

17) What is the tension in the rope when the soap is level with her hand?

$$\sum F_h = m \cdot a_h = m \cdot a_c = \frac{mv^2}{r}$$

$$+T = \frac{6 \cdot (5)^2}{3} = \boxed{T = 50N}$$

18) What is the tension in the rope when the soap is directly below her hand?

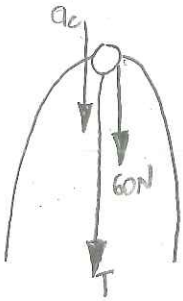


$$\sum F_v = m \cdot a_v = \frac{mv^2}{r}$$

$$(-60) + (T) = \frac{6(5)^2}{3}$$

$$T = 50N + 60N \qquad \boxed{T = 110N}$$

19) What is the tension in the rope when the soap is directly above her hand?

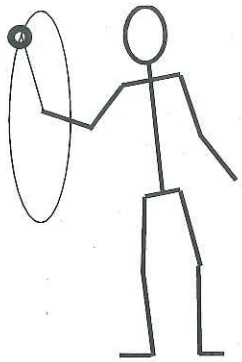


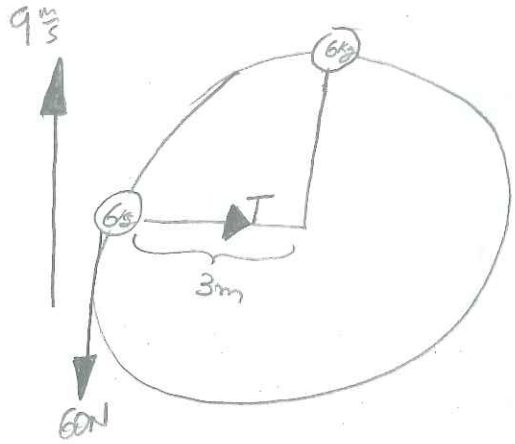
$$\sum F_v = m \cdot a_c = \frac{mv^2}{r}$$

$$(-T) + (-60N) = -\left(\frac{6 \cdot 50}{3}\right)$$

$$-T = -50 + 60$$

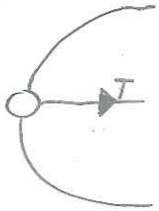
$$\boxed{T = -10N}$$





A student has a 'Soap on a Rope'. She spins the soap in a circular path. The radius of the path is 3m. The circle is in the vertical plane. The mass of the soap is 6kg. The mass of the rope is negligible. She spins the soap at a tangential speed of 9m/s.

20) What is the tension in the rope when the soap is level with her hand?

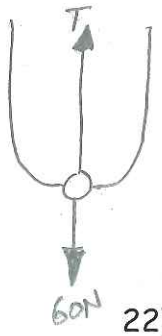


$$\Sigma F_h = m \cdot a_h = \frac{m \cdot v^2}{r}$$

$$T = \frac{6(9)^2}{3}$$

$$\boxed{T = 162N}$$

21) What is the tension in the rope when the soap is directly below her hand?



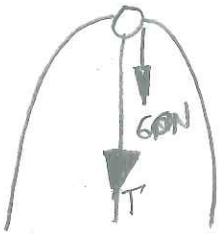
$$\Sigma F_v = \frac{m \cdot v^2}{r}$$

$$+T + (-60N) = \frac{6 \cdot 81}{3}$$

$$T = 162 + 60N$$

$$\boxed{T = 222N}$$

22) What is the tension in the rope when the soap is directly above her hand?



$$\Sigma F_v = \frac{m \cdot v^2}{r}$$

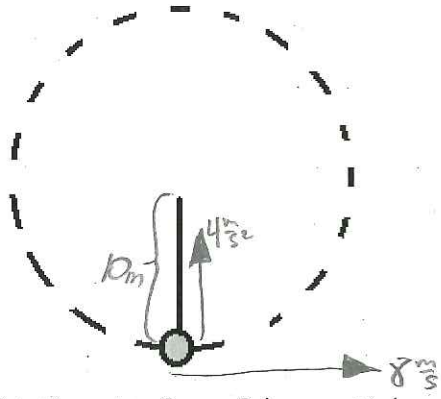
$$(-T) + (-60N) = -\frac{6 \cdot 81}{3}$$

$$-T = -162N + 60N$$

$$-T = -102N$$

$$\boxed{T = 102N}$$

Non-uniform circular motion



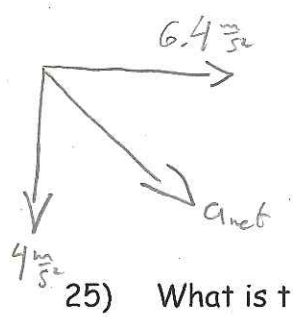
At time t = 0 s a 2 kg particle revolves with a tangential velocity of +8 m/s in a circular path of radius 10 m. The particle revolves in a horizontal circle. The particle's rate of revolution is increasing in such a way that the particle has a tangential ~~acceleration~~ of +4 m/s^2.

23) What is the particle's centripetal acceleration at time t = 0 s?

Find $a_c = \frac{v^2}{r}$

$a^2 = \frac{8^2}{10} = \boxed{6.4}$

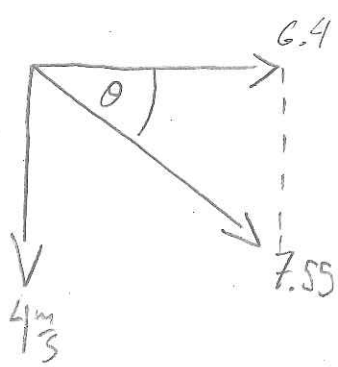
24) What is the particle's net acceleration at time t = 0 s?



$a_{net} = \sqrt{4^2 + 6.4^2}$

$\boxed{a_{net} = 7.55 \text{ m/s}^2}$

25) What is the angle between the particle's net acceleration and the particle's centripetal acceleration?

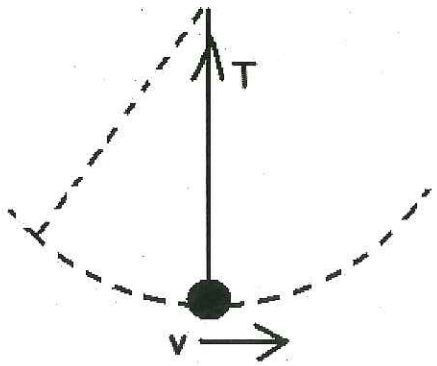


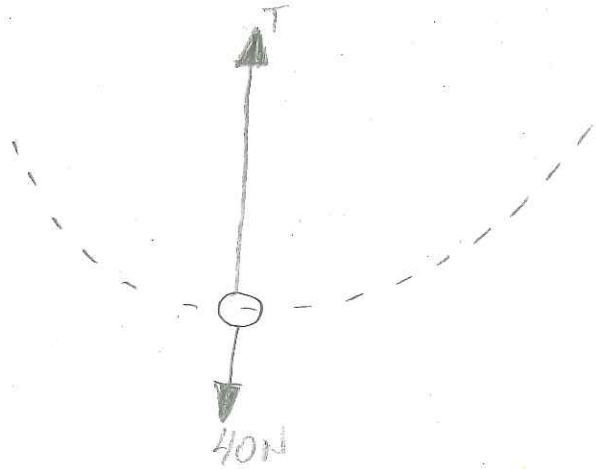
$\tan\theta = \frac{4}{6.4}$

$\theta = \tan^{-1}\left(\frac{4}{6.4}\right)$

$\boxed{\theta = 32.0}$

26) Draw a scale vector diagram to confirm the angle between the particle's net acceleration and the particle's centripetal acceleration.





A 4kg ball is attached to a branch by a string that is 2m long. The ball is swung in an arc forming a pendulum. The speed of the ball at its lowest point is 5 m/s.

27) What is the weight of the ball?

$$W = m \cdot g = 4 \cdot 10 = 40N$$

28) What would be the tension in the string if the ball hung vertically without moving?

$$\Sigma F_v = 0$$

$$T - 40N = 0$$

$$T = 40N$$

29) What is the tension in the string at its lowest point in the swing while it is moving?

$$\Sigma F_v = m \cdot a_c = \frac{m \cdot v^2}{r}$$

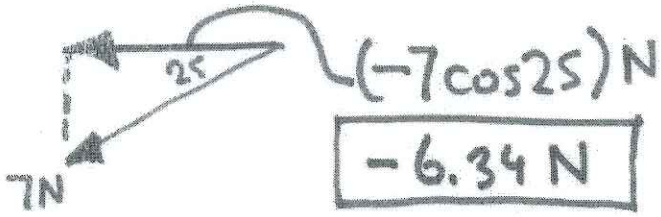
$$T - 40N = \frac{4\,Kg\,(5\,\frac{m}{s})^2}{2m}$$

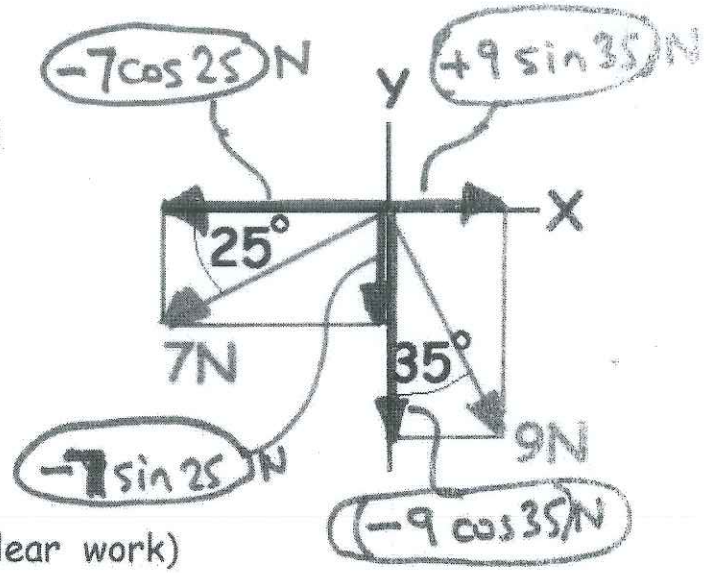
$$T = 50N + 40N$$

$$\boxed{T = 90N}$$

20) Consider this vector diagram.

- What is x component of the 7N vector?



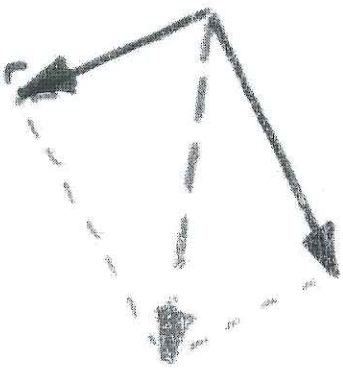


- What is the magnitude of the resultant vector? (Must show clear work)

X Y Z

$(+9\sin 35)i + (-9\cos 35)j + (0)k$ } 9N vector

$(-7\cos 25)i + (-7\sin 25)j + (0)k$ } 7N vector



$(+5.16\,i) + (-7.37\,j) + (0k)$

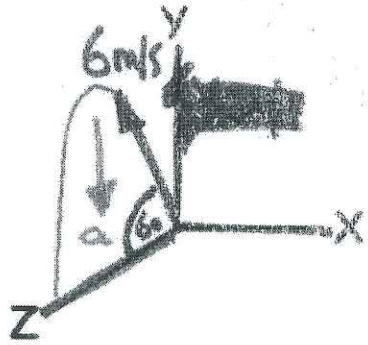
$(-6.34i) + (-2.96j) + (0k)$

$(-1.18i) + (-10.33j) + (0k)$

$\text{mag} = \sqrt{a^2+b^2+c^2} = \sqrt{(-1.18)^2 + (-10.33)^2 + (0)^2} = \boxed{10.40\text{ N}}$

21) A football's is kicked at 6m/s in a direction that is inclined at 60° elevation above the positive Z axis.

- Express this initial velocity as an 'ijk' vector.



$(0\hat{i}) + (+6\sin 60\,\hat{j}) + (+6\cos 60\,\hat{k})$

$(0\hat{i}) + (5.20\,\hat{j}) + (3.00\,\hat{k})$

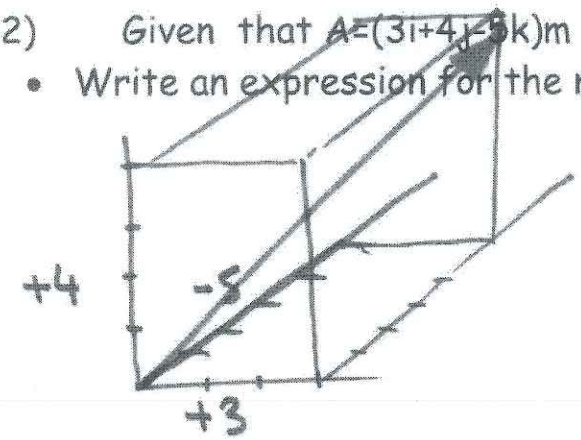
$\boxed{(0\hat{i} + 5.20\hat{j} + 3.00\hat{k})\text{ m/s}}$

- Express the acceleration due to gravity as an 'ijk' vector.

$\vec{a} = (0\hat{i}) + (-10\hat{j}) + (0\hat{k}) = \boxed{(0\hat{i} - 10\hat{j} + 0\hat{k})\text{ m/s}^2}$

22) Given that A=(3i+4j-5k)m

- Write an expression for the magnitude of this vector.



$$mag = \sqrt{a^2 + b^2 + c^2}$$

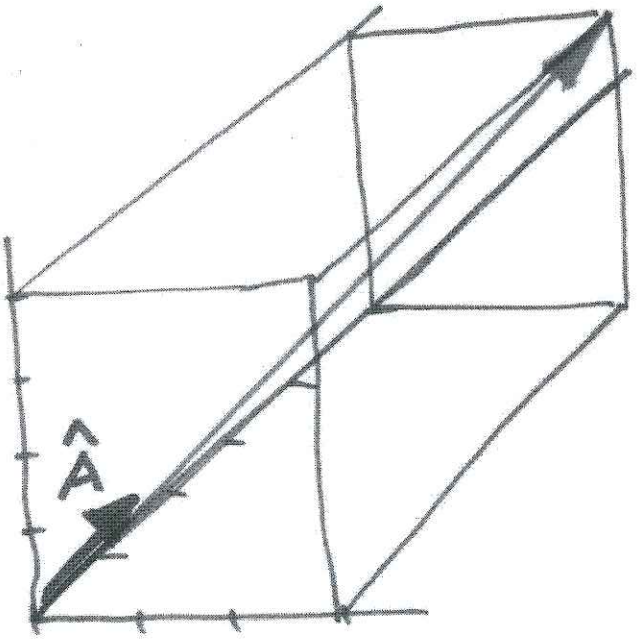
$$mag = \sqrt{(+3)^2 + (+4)^2 + (-5)^2}$$

$$mag = \sqrt{9 + 16 + 25} = \sqrt{50}$$

$$mag = \boxed{7.07\,m}$$

- Write an expression for the unit vector that has the same direction as this vector.

$\vec{A} = (3i + 4j - 5k)\,m$



($\hat{A}$ is in same direction as $\vec{A}$ but has a length (magnitude) of 1m).

$$\hat{A} = \frac{\vec{A}}{mag\,\vec{A}}$$

$$\hat{A} = \frac{(3i + 4j - 5k)}{\sqrt{(3)^2 + (4)^2 + (-5)^2}}$$

$$\hat{A} = \boxed{\frac{3i + 4j - 5k}{7.07}}$$

48 T1 SU11 **Name** _____

For credit, all work must be shown clearly.

1a) Express 3mg in standard units?

$3\times10^{-3}g = \boxed{3\times10^{-6}Kg}$

1b) What are the dimensions of C if $C=\frac{2B^2L}{V}$
(where B is a mass, L is a length and V is a velocity).

$\frac{2[M]^2[L]}{\frac{[L]}{[T]}} = 2[M]^2\cancel{[L]}\cdot\frac{[T]}{\cancel{[L]}} = \boxed{[M]^2[T]}$

units only

1c) Express $3\mu m^3$ in m^3.

$\boxed{3\times10^{-18}m^3}$

1d) Divide these two numbers, quoting your answer with the appropriate rounding and significant digits. (121.45m / 7.21s)

$\frac{121.45m}{7.21s} = \boxed{16.8\frac{m}{s}}$

1e) Convert 7.3 kips/second into km/minute. (1kip=4m)

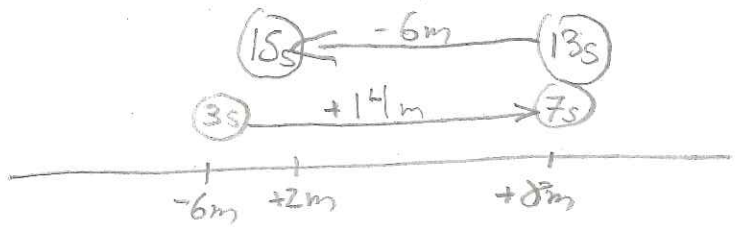
$\frac{7.3\,Kips}{Sec}\cdot\frac{60\,sec}{1\,min}\cdot\frac{4\,m}{1\,Kips}\cdot\frac{1\,Km}{1000\,m} = \boxed{1.8\frac{Km}{min}}$?

or

$\boxed{1.75\frac{Km}{min}}$

An particle is at position -6m at t=3s. It then takes 4s to move to position +8m. At position +8m it is stationary for 6s. Finally it moves to the left for 2s travelling at a speed of 3m/s. (Right is positive and left is negative).

$V = \frac{\Delta x}{T}$



2a) What is its displacement resulting from this journey?

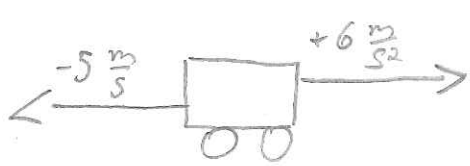
$\Delta x = x_f - x_i \rightarrow \Delta x = +2m - (-6m)$

$\boxed{\Delta x = +8m}$

2b) What is the object's average velocity during this journey?

$\bar{v} = \frac{\Delta x}{\Delta T} = \frac{x_f - x_i}{T_f - T_i} = \frac{2m - (-6m)}{15s - 3s} = \frac{8m}{12s} = \frac{2}{3}\frac{m}{s} = \boxed{+0.67\frac{m}{s}}$

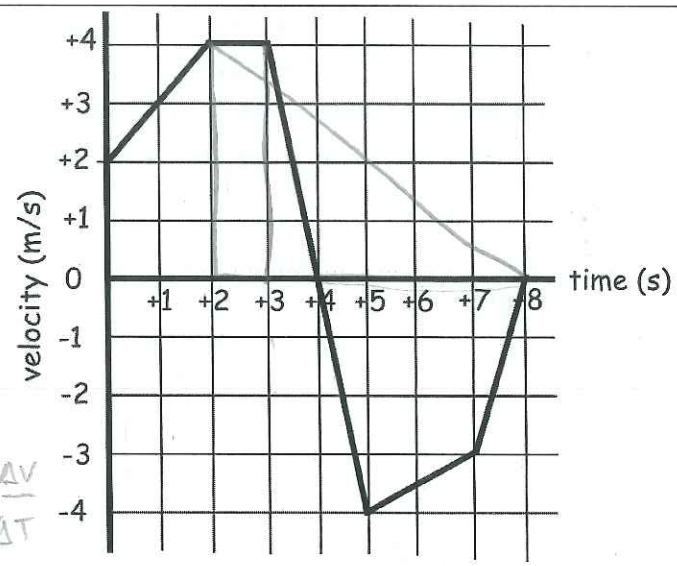
2c) The motion of a model car is monitored. At t=4s it has an instantaneous acceleration of +6m/s² and an instantaneous speed of -5m/s. What is its direction of travel and is it speeding up or slowing down?



Traveling in a negative direction while slowing down

? Travelling to the lef (positive v)?

Consider the graph, which depicts the journey of a particle that is moving on the X-axis.



2d) What is the particle's instantaneous velocity at t=6s?

$V = -3.5 \frac{m}{s}$

2e) What is the particle's average acceleration between t=2s and t=8s?

$-\frac{4}{6} \frac{m}{s^2} = -0.67 \frac{m}{s^2}$? or $\frac{\Delta V}{\Delta T}$

2f) When does the particle start travelling in a negative direction for the first time?

at $T = +4s$

2g) What displacement results from the first 3 seconds of the journey?

? Area under curve $= \frac{1}{2}(2+4)3 = \boxed{9m}$

why 10m?

A particle moves along the x-axis according to the equation: $x=2t^2-3$ m (where x is in meters and t is in seconds).

2h) Determine the objects position at t=3s.

$X = 2(3)^2 - 3$

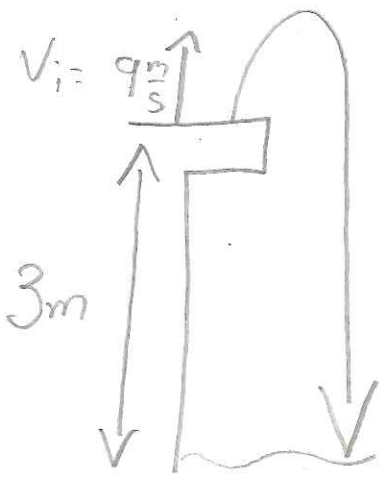
$\boxed{X = 15m}$

2i) Determine the objects instantaneous acceleration at t=3s.

$X' = 4t$

$\boxed{X'' = 4 \frac{m}{s^2}}$

2j) A student jumps vertically up, off of a diving board, with a speed of 9m/s. The diving board is 3m above the water. With what velocity does she reach the water?



$V_i = 9\frac{m}{s}$

$\Delta X = -3m$

$a = -10\frac{m}{s^2}$

$V_f^2 = V_i^2 + 2a\Delta X$

$V_f^2 = (9)^2 + 2(-10)(-3)$

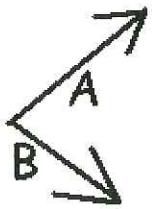
$V_f^2 = 81 + 60$

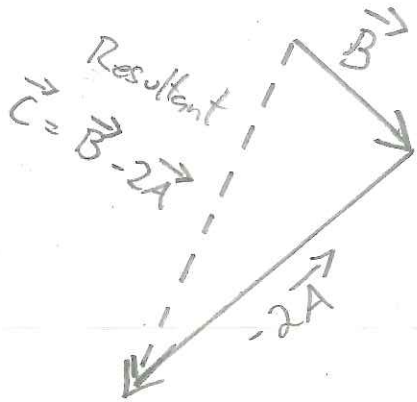
$V_f = \pm\sqrt{141} \rightarrow \boxed{V_f = 11.9}$

3a) Circle the vectors in the following list?

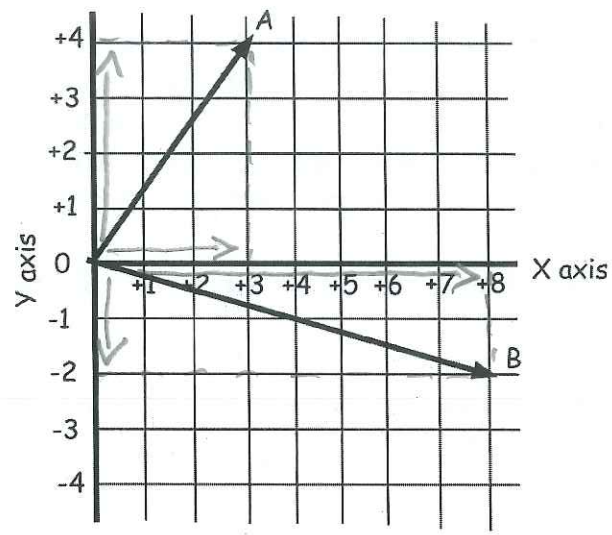
displacement, temperature, mass, velocity

3b) Carefully draw a vector diagram (to scale using a straight edge) to determine **C** if **C**=**B**-2**A**. Clearly indicate vector **C** in your diagram.





Two forces act on a particle.
Both forces act in the X-Y plane.



3c) Express the net force that results from adding these two vectors together, in 'ijk' vector notation.

$\vec{A} = (+3\hat{i} + 4\hat{j} + 0\hat{k})$

$\vec{B} = (+8\hat{i} - 2\hat{j} + 0\hat{k})$

$\boxed{(11\hat{i} + 2\hat{j} + 0\hat{k})}$

3d) Determine the magnitude of the resultant vector.

$mag = \sqrt{(11)^2 + (2)^2 + (0)^2} = mag = \sqrt{125}$

$\boxed{mag = 11.18 \frac{m}{s}}$

3e) Express the direction of the resultant as a unit vector.

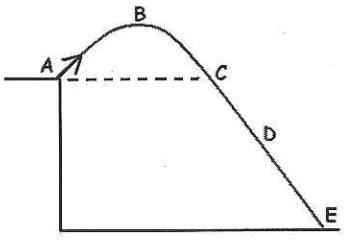
$\cancel{11.18 \cos\theta = 11}$

$\cancel{\theta = \cos^{-1}\left(\frac{11}{11.18}\right)}$

$\cancel{\theta = 10.3°}$

$\boxed{\left(\frac{11\hat{i} + 2\hat{j} + 0\hat{k}}{11.18 \frac{m}{s}}\right)}$

This diagram represents the path of a ball being thrown off a 9m tall cliff. The ball was thrown from A at a velocity of 2m/s at and angle of 40° elevation above the horizontal. Air resistance can be ignored.



4a) When is the ball in free fall?

from the moment it is thrown at A

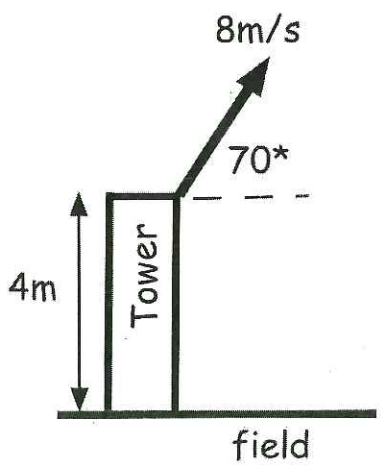
4b) What is the horizontal component of the ball's acceleration at point B?

horizontal acceleration at $0 \frac{m}{s^2}$

4c) What is the vertical component of the ball's displacement at point C?

at $\boxed{9m}$ $\therefore \Delta X = X_F - X_i = 9 - 9m = \boxed{0m}$

4d) A rock is thrown from the top of a 4m tall tower with a speed of 8m/s at an angle of elevation above the horizontal of 70 degrees. What is the rocks horizontal range as it lands on the field?



Range using hor info

$V_i = 8\cos 70$
$\Delta X = ?$
$a = 0$
$\Delta T = ?$

$\Delta X = V_i \Delta T + \frac{1}{2} a \Delta T^2$

$\Delta X = 8\cos 70 (1.92) - 0(3.69)$

$\boxed{\Delta X = 5.25m}$

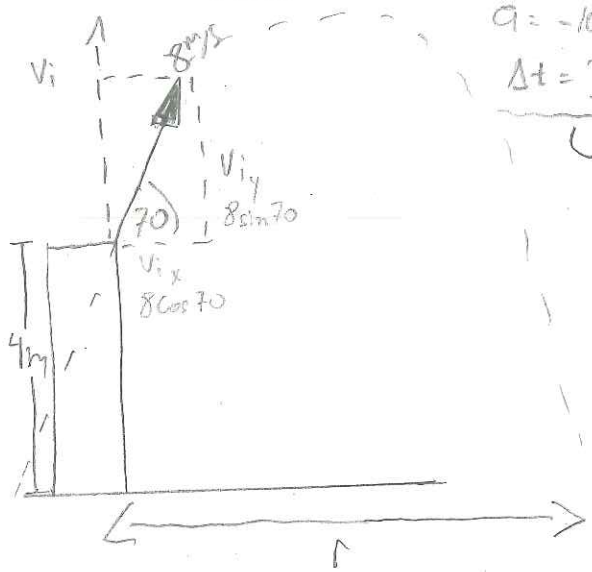
Find ΔT using vert info

$V_i = 8\sin 70$
$\Delta X = -4m$
$a = -10 \frac{m}{s^2}$
$\Delta t = ?$

$\Delta X = V_i \Delta T + \frac{1}{2} a \Delta T^2$

$-4 = (8\sin 70)T - 5T^2$

$-5T^2 + 8\sin 70\, T + 4$



Find using vert info

$V_f^2 = V_i^2 + 2a\Delta X$

$V_f^2 = (8\sin 70)^2 + (-20)(-4)$

$V_f = -11.7 \frac{m}{s}$

Find ΔT

$V_f = V_i + a\Delta T$

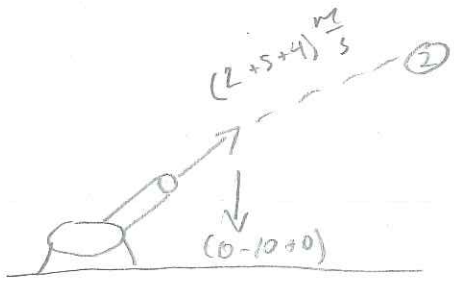
$-11.7 = 8\sin 70 - 10T$

$-10T = -11.7 - 8\sin 70$

$T = \frac{-4.18}{-10}$

$\boxed{\Delta T = 1.92}$

4e) A 2kg cannonball is fired at t=0s with a muzzle velocity of (2**i**+5**j**+4**k**) *m/s*. Express, using 'ijk' vector notation, the cannonball's velocity at t=4s.



$V_i = 2+5+4$

$\Delta T = 4s$

$a = (0-10+0)$

$V_f = ?$

$V_f = V_i + a\Delta T$

$V_f = (2+5+4) + (0-40+0)$

$V_f = (2i - 35j + 4k)$

4f) The velocity of particle A relative to particle B is v_{AB}=(3**i**-2**j**-3**k**) **m/s**. The velocity of particle C relative to particle B is v_{CB}=(3**i**+2**j**-4**k**). What is the velocity of particle C relative to particle A?

$V_{AB} = (3-2-3)$

$V_{CB} = (3+2-4)$

$V_{BA} = -V_{AB} = (-3+2+3)$

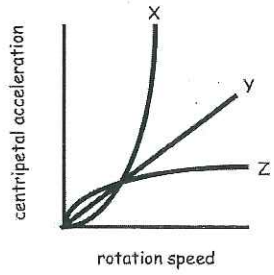
$V_{CB} + V_{BA} = V_{CA}$

$(3+2-4)$
$+(-3+2+3)$

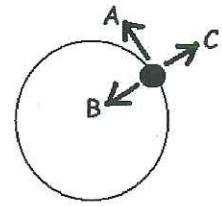
$\boxed{0i + 4j - 1k \ \frac{m}{s}}$

A 4kg ball moves in a counter-clockwise circular orbit with a steady speed.

4g) A student plots a graph of the ball's centripetal acceleration versus the ball's speed. Which trace (X, Y or Z) should the student draw?



4h) In which direction, (A, B, or C), does the centripetal acceleration act?



48 T1 SU12 Name _____

For credit, all work must be shown clearly.

1a) Express 1.4ng using the standard SI unit.

$1.4 \times 10^{-9} g = \boxed{1.4 \times 10^{-12} kg}$

1b) What are the dimensions of C if $\mathbf{C} = \frac{1}{2}\left(\frac{XB}{v^2}\right)$

(where X is a length, B is a mass, and v is a velocity).

$\frac{[L][M]}{\frac{[L]^2}{[T]^2}} = \cancel{[L]}[M] \cdot \frac{[T]^2}{[\cancel{L}]^2} = \boxed{\frac{[M][T]^2}{[L]}}$

1c) Express 3.4mm³ using the standard SI unit.

$\boxed{3.4 \times 10^{-9} m^3}$

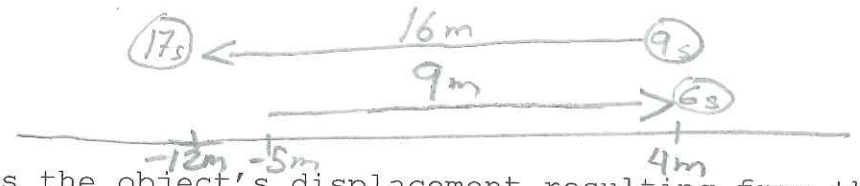
1d) Perform this subtraction, quoting your answer with the appropriate rounding and significant digits. 434.1m - 413.37m

$434.1m - 413.37m = \boxed{20.7m}$

1e) Convert 6 naps/jup into mm/s. (8jup=5s ; 4nap=3m)

$\frac{6 \text{ naps}}{\text{jup}} \cdot \frac{8 \text{ jup}}{5 s} \cdot \frac{3 m}{4 \text{ nap}} \cdot \frac{1000 mm}{1 m} = = \boxed{7200 \frac{mm}{s}}$

2a) An object starts at position -5m. It moves 9m the right, taking 6s. It is then stationary for 3s. It then moves at a steady 2m/s to the left for 8s. (Right is positive and left is negative).



$V = \frac{\Delta x}{T}$

2ai) What is the object's displacement resulting from this journey?

$\Delta X \rightarrow \Delta X = X_F - X_i$

$\Delta X = -12m - (-5)$ $\boxed{\Delta X = -7m}$

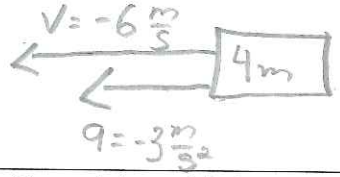
2aii) What distance did the object travel during this journey?

$DT = 9m + 16m$ $\boxed{DT = 25m}$

2aiii) What is the object's average velocity during this journey?

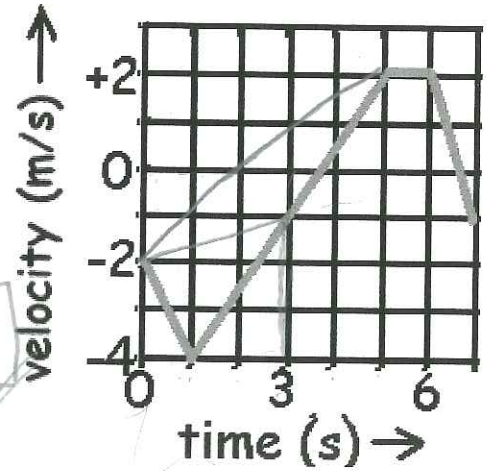
$\bar{V} = \frac{\Delta X}{\Delta T} = \frac{X_F - X_i}{T_F - T_i} = \frac{-12m - (5m)}{17s - 0s} = \frac{-7m}{17s} = \boxed{\bar{V} = -0.412 \frac{m}{s}}$

2b) A particle is passing the point x=+4m. It has an instantaneous velocity of -6m/s. It has an instantaneous acceleration of -3m/s². What is its direction of travel and is it speeding up or slowing down?



Direction of travel is in a negative (Left) direction & speeding up

2c) Consider this graph, which depicts the journey of a particle that is moving on the X-axis.



2ci) At what instant, after the start, does the particle first change direction?

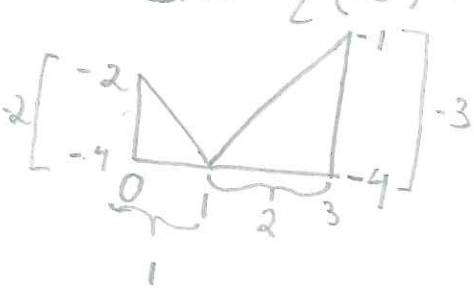
At T = 3.66 s

2cii) What is the particle's average acceleration for the first 5 seconds of this journey?

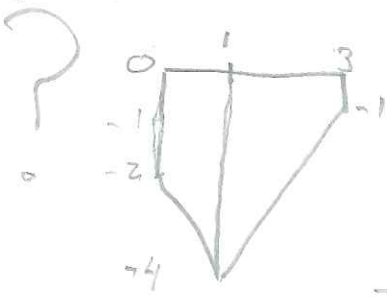
$\bar{a} = \frac{V_F - V_i}{T_F - T_i} = \frac{+2 - (-2)}{5 - 0} = \frac{4}{5} \frac{m}{s^2} = \boxed{0.8 \frac{m}{s}}$

2ciii) What is the particle's displacement resulting from the first 3s of this journey?

$\Delta X = \frac{1}{2}(-2) + \frac{1}{2}(-3)2 = \boxed{\Delta X = -4m}$



?



$\frac{1}{2}(-2 + (-4))1 + \frac{1}{2}(-1 + (-4))2 = \boxed{-8m}$

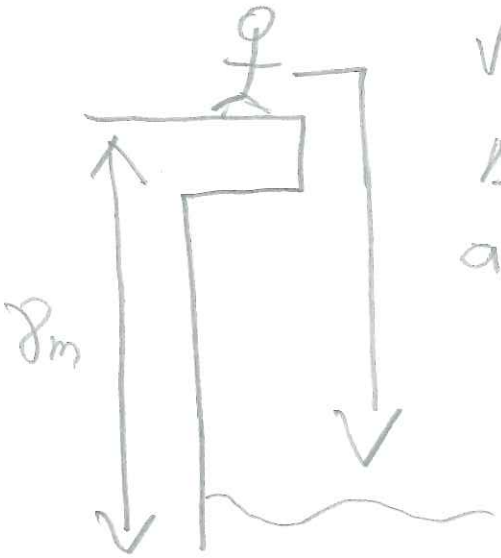
A particle moves along the x-axis according to the equation: $x=3t^2+6t-4$ m (where x is in meters and t is in seconds).

2d) Using calculus determine the objects instantaneous acceleration at t=5s.

$x' = 6t + 6$

$\boxed{x'' = 6 \frac{m}{s^2}}$

2e) A 5kg student steps off a diving board that is 8m above the water. What is her velocity as she reaches the water?



$V_i = 0$

$V_f = ?$

$\Delta x = -8m$

$a = -10$

$V_f^2 = V_i^2 + 2a\Delta x$

$V_f^2 = 0 + 2(-10)(-8)$

$V_f^2 = 160$

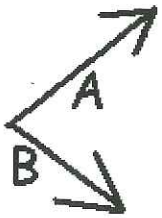
$V_f = \pm\sqrt{160}$

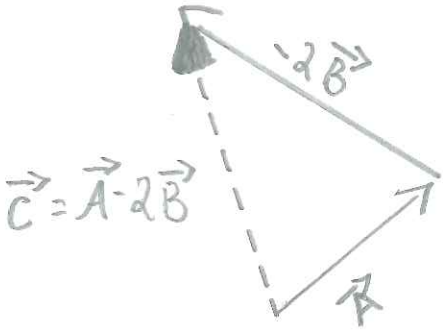
$\boxed{V_f = -12.65 \frac{m}{s}}$

3a) Circle the scalars in the following list?

mass, displacement, speed, temperature, acceleration

3b) Draw a vector diagram (to scale using a straight edge) to determine **C** if **C=A-2B**. Clearly indicate vector **C** in your diagram.



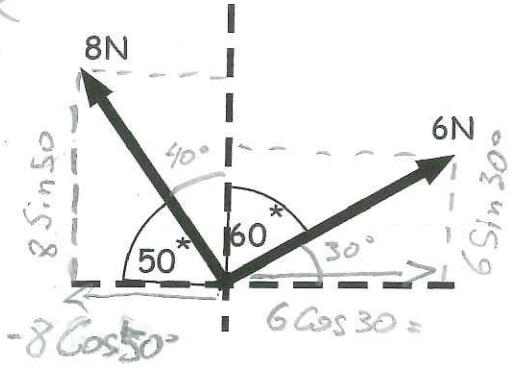


3c) Two forces act on particle as shown in the vector diagram.

3ci) Using 'ijk' vector notation, state the resultant force that results from adding these two forces together.

i	j	K
6 Cos 30	6 Sin 30	0
-8 Cos 50	8 Sin 50	0

$$\boxed{0.054\hat{i} + 9.128\hat{j} + 0\hat{k}}$$



3cii) Determine the magnitude of the resultant vector.

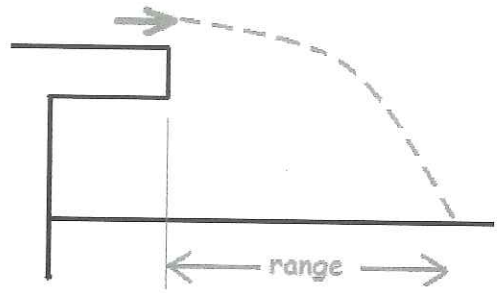
$$mag = \sqrt{(.054)^2 + (9.128)^2} \qquad mag = \sqrt{83.323}$$

$$\boxed{mag = 9.128\ N}$$

3ciiii) Determine the direction of the resultant expressed as a unit vector.

$$\boxed{\frac{(0.054\hat{i} + 9.128\hat{j} + 0\hat{k})N}{9.128}}$$

4a) Consider the diagram. It represents the path of a ball that is rolled off a 3m tall diving board. Air resistance can be ignored.



4ai) What is the vertical component of the ball's velocity as it leaves the board?

0 m/s

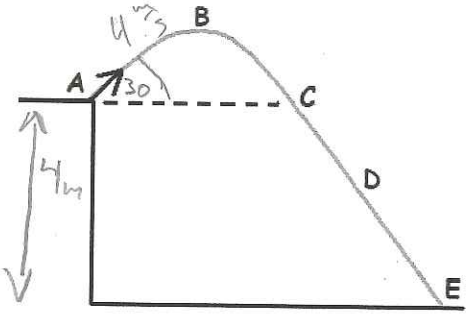
4aii) What is the vertical component of the ball's displacement for the entire journey?

-3 m

4aiii) What is the horizontal component of the ball's acceleration as it leaves the board?

0

4b) A ball is fired at 4m/s muzzle velocity at 30* elevation above the horizontal, from the edge of a cliff that is 4m above a lake. Using some of the four kinematic equations, determine its range? (Must show work)



Find ΔX using hor info

$\Delta X = ?$	$\Delta X = V_i \Delta T + \frac{1}{2} a \Delta T^2$
$V_{ix} = 4\cos 30$	$\Delta X = 4\cos 30 (1.11) + 0$
$a = 0$	$\boxed{\Delta X = 3.868 m}$
$\Delta T = ?$	

Find ΔT using vert info

$\Delta X = -4m$	$V_f^2 = V_i^2 + 2a\Delta X$
$a = -10 \frac{m}{s^2}$	$V_f^2 = (4\sin 30)^2 - 20(-4)$
$V_i = 4\sin 30$	$V_f^2 = 81$
$V_f = ?$	$\boxed{V_f = -9.17}$
$\Delta T = ?$	

$V_f = V_i + a\Delta T$

$\Delta T = \frac{V_f - V_i}{a} = \frac{-9.17 - (4\sin 30)}{-10} = \boxed{1.11 s}$

4c). At t=2s, a red, 6kg particle, moving with constant acceleration of (**-3i+2j+4k**) *m/s²*, has a velocity of (**+2i-3j+2k**) *m/s* and is at the origin. State the particle's displacement at t=6s using 'ijk' vector notation.

$(-3i+2j+4k)\ \frac{m}{s^2}$

$(2i-3j+2k)\ \frac{m}{s}$

$\Delta T = 4s$

$V_i = (2-3+2)$

$a = (-3+2+4)$

$\Delta X = V_i \Delta T + \frac{1}{2} a \Delta T^2$

$\Delta X = (2-3+2)(4) + \frac{1}{2}(-3+2+4)(16)$

$\Delta X = (8-12+8) + (-24+16+32)$

$\Delta X = (-16i + 4j + 40k)$

4d) The velocity of an asteroid relative to a the Moon is (**-4i+3j+1k**) *m/s*. The velocity of the International Space Station relative to The Asteroid is (**-2i+5j-2k**) *m/s*. Express the velocity of the Moon relative to the International Space Station in 'ijk' vector notation?

$V_{AM} = (-4$

48 T1 SU12 **Name** (KEY)

For credit, all work must be shown clearly.

1a) Express 1.4ng using the standard SI unit.

$1.4\,ng = 1.4\times10^{-9}\,g = \boxed{1.4\times10^{-12}\,kg}$ 1

1b) What are the dimensions of C if $C=\frac{1}{2}\left(\frac{XB}{v^2}\right)$

(where X is a length, B is a mass, and v is a velocity).

$$\frac{[L][M]}{\left(\frac{[L]}{[T]}\right)^2} = \frac{[L][M]}{\frac{[L]^2}{[T]^2}} = \frac{[L][M][T]^2}{[L]^2} = \boxed{\frac{[M][T]^2}{[L]}}$$ 1

1c) Express $3.4mm^3$ using the standard SI unit.

$$\frac{3.4\,mm^3}{} \left| \frac{1\,m^3}{10^9\,mm^3} \right. = \boxed{3.4\times10^{-9}\,m^3}$$ 1

1d) Perform this subtraction, quoting your answer with the appropriate rounding and significant digits. 434.1m - 413.37m

$434.1 - 413.37 = 20.73$

USE DECIMAL PLACES

$\boxed{20.7\,m}$ 1

1e) Convert 6 naps/jup into mm/s. (8jup=5s ; 4nap=3m)

$$\frac{6\,naps}{1\,jup} \left| \frac{3\,m}{4\,naps} \right| \frac{8\,jup}{5\,s} \left| \frac{1000\,mm}{1\,m} \right. = \boxed{7200\,mm/s}$$

1

2a) An object starts at position -5m. It moves 9m the right, taking 6s. It is then stationary for 3s. It then moves at a steady 2m/s to the left for 8s. (Right is positive and left is negative).

2ai) What is the object's displacement resulting from this journey?

$\Delta x = x_f - x_i = (-12) - (-5) = \boxed{-7m}$ 1

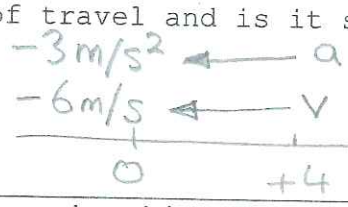
2aii) What distance did the object travel during this journey?

$(5) + (4) + (16) = \boxed{25m}$ 1

2aiii) What is the object's average velocity during this journey? 1

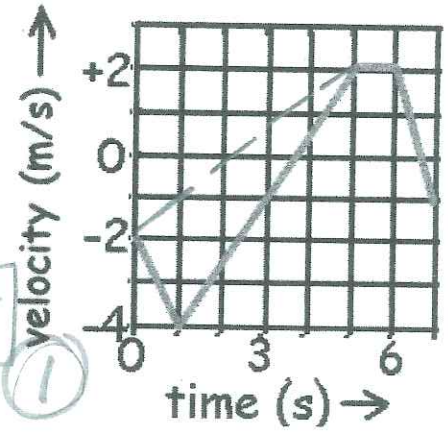
$\bar{v} = \frac{\Delta x}{\Delta t} = \frac{x_f - x_i}{t_f - t_i} = \frac{(-12) - (-5)}{(17) - (0)} = \frac{-7}{17} = \boxed{-0.412 \text{ m/s}}$

2b) A particle is passing the point x=+4m. It has an instantaneous velocity of -6m/s. It has an instantaneous acceleration of $-3m/s^2$. What is its direction of travel and is it speeding up or slowing down?



TRAVELLING LEFT
SPEEDING UP 1

2c) Consider this graph, which depicts the journey of a particle that is moving on the X-axis.



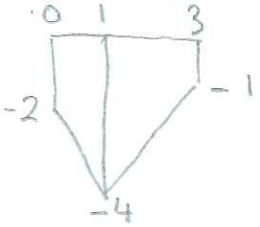
2ci) At what instant, after the start, does the particle first change direction?

$\boxed{3.66s}$ BY INSPECTION 1

2cii) What is the particle's average acceleration for the first 5 seconds of this journey?

$\bar{a} = \frac{\Delta v}{\Delta t} = \frac{v_f - v_i}{t_f - t_i} = \frac{(+2) - (-2)}{(5) - (0)} = \boxed{+0.8 m/s^2}$ 1

2ciii) What is the particle's displacement resulting from the first 3s of this journey?



$\text{AREA} = \frac{1}{2}((-2) + (-4))1 + \frac{1}{2}((-4) + (-1))2$

$= \left(-\frac{6}{2}\right) + \left(-\frac{10}{2}\right) = \boxed{-8m}$ 1

A particle moves along the x-axis according to the equation: $x=3t^2+6t-4$ m (where x is in meters and t is in seconds).

2d) Using calculus determine the objects instantaneous acceleration at t=5s.

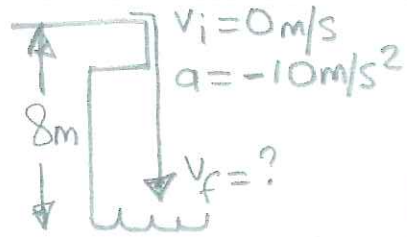
$x = 3t^2 + 6t - 4$

$v = \frac{dx}{dt} = 6t + 6 \quad a = \frac{d^2x}{dt^2} = +6$

$\boxed{+6\ m/s^2}$

1

2e) A 5kg student steps off a diving board that is 8m above the water. What is her velocity as she reaches the water?



$v_i = 0\ m/s$
$a = -10\ m/s^2$
$\Delta x = -8\ m$
$v_f = ?$

$v_f^2 = v_i^2 + 2a\Delta x$

$v_f^2 = 0^2 + 2(-10)(-8)$

$v_f^2 = +160$

$v_f = +$ or $-$ $12.65\ m/s$

$\boxed{v_f = -12.65\ m/s}$

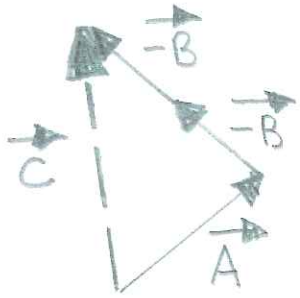
2

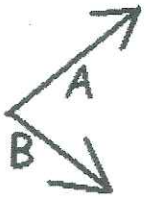
3a) Circle the scalars in the following list? ALL OR NOTHING

mass, displacement, speed, temperature, acceleration

1

3b) Draw a vector diagram (to scale using a straight edge) to determine **C** if **C=A-2B**. Clearly indicate vector **C** in your diagram.





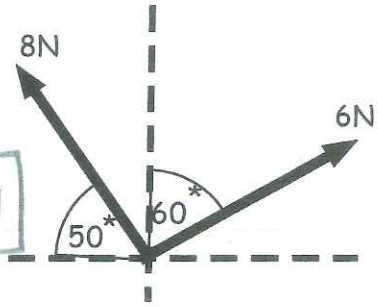
1

3c) Two forces act on particle as shown in the vector diagram.

3ci) Using 'ijk' vector notation, state the resultant force that results from adding these two forces together.

i	j	k
$(+6\sin 60)$	$(+6\cos 60)$	(0)
$(-8\cos 50)$	$(+8\sin 50)$	(0)

$$\boxed{(+0.054i + 9.128j + 0k)N}$$



2

3cii) Determine the magnitude of the resultant vector.

$$mag = \sqrt{(0.054)^2 + (9.128)^2 + (0)^2}$$

$$\boxed{mag = 9.128\ N}$$

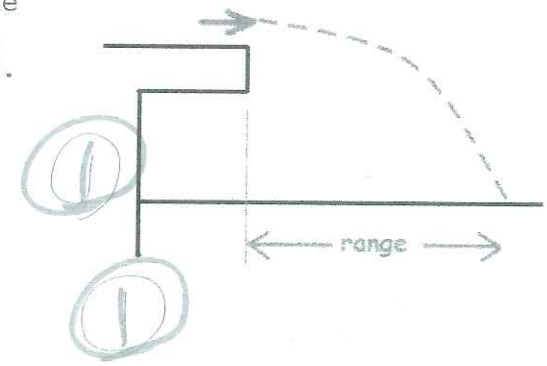
1

3ciiii) Determine the direction of the resultant expressed as a unit vector.

$$\boxed{\hat{r} = \frac{0.054}{9.128}\hat{i} + \frac{9.128}{9.128}\hat{j} + \frac{0}{9.128}\hat{k}}$$

1

4a) Consider the diagram. It represents the path of a ball that is rolled off a 3m tall diving board. Air resistance can be ignored.



4ai) What is the vertical component of the ball's velocity as it leaves the board?

$\boxed{0\,m/s}$

1

4aii) What is the vertical component of the ball's displacement for the entire journey?

$\boxed{-3m}$

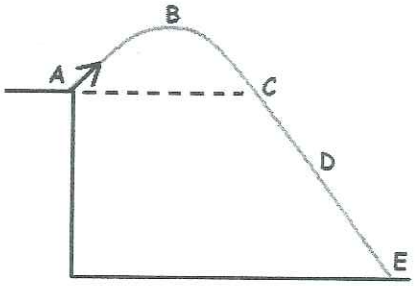
1

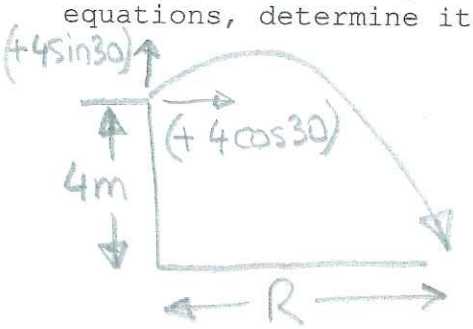
4aiii) What is the horizontal component of the ball's acceleration as it leaves the board?

$\boxed{0\,m/s^2}$

1

4b) A ball is fired at 4m/s muzzle velocity at 30* elevation above the horizontal, from the edge of a cliff that is 4m above a lake. Using some of the four kinematic equations, determine its range? (Must show work)





FIND R USING HOR INFO

$V_i = +4\cos 30$ m/s
$a = 0\,m/s^2$
$\Delta t =$
$\Delta x = ?$

$\Delta x = V_i \Delta t + \frac{1}{2} a \Delta t^2$
$\Delta x = (+4\cos 30)\Delta t + \frac{1}{2}(0)\Delta t^2$
$\Delta x = (+4\cos 30)\Delta t = \boxed{3.868\,m}$

FIND Δt USING VERT INFO

$V_i = +4\sin 30$ m/s
$a = -10\,m/s^2$
$\Delta x = -4m$
$\Delta t =$

$\Delta x = V_i \Delta t + \frac{1}{2} a \Delta t^2$
$(-4) = (+4\sin 30)\Delta t + \frac{1}{2}(-10)\Delta t^2$
$-5\Delta t^2 + 4\sin 30\,\Delta t + 4 = 0$
$\Delta t = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$

$\Delta t = \frac{-2 \pm \sqrt{4 - (4)(-5)(4)}}{-10} = +1.117s \quad -0.717s$

2

4c) At t=2s, a red, 6kg particle, moving with constant acceleration of (-3**i**+2**j**+4**k**) *m/s²*, has a velocity of (+2**i**-3**j**+2**k**) *m/s* and is at the origin. State the particle's displacement at t=6s using 'ijk' vector notation.

$V_i = (+2\hat{i} - 3\hat{j} + 2\hat{k})\ m/s$

$a = (-3\hat{i} + 2\hat{j} + 4\hat{k})\ m/s^2$

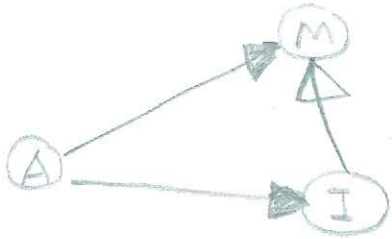
$\Delta t = t_f - t_i = 6 - 2 = 4s$

$\vec{\Delta r} = \vec{V_i}\Delta t + \frac{1}{2}\vec{a}\Delta t^2$ 1

i	j	k	
+8	-12	+8	$V_i \Delta t$
-24	+16	+32	$\frac{1}{2} a \Delta t^2$

$\boxed{(-16\hat{i} + 4\hat{j} + 40\hat{k})\ m}$ 2

4d) The velocity of an asteroid relative to a the Moon is (-4**i**+3**j**+1**k**) *m/s*. The velocity of the International Space Station relative to The Asteroid is (-2**i**+5**j**-2**k**) *m/s*. Express the velocity of the Moon relative to the International Space Station in 'ijk' vector notation?



$\vec{V_{AM}} = (-4\hat{i} + 3\hat{j} + 1k)\ m/s$

$\vec{V_{IA}} = (-2\hat{i} + 5j - 2k)\ m/s$

$V_{MI} = ?$

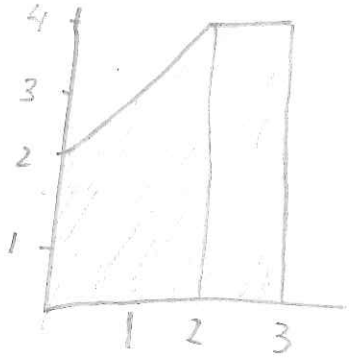
$\vec{V_{MI}} = \vec{V_{MA}} + \vec{V_{AI}}$

i	j	k
+4	-3	-1
+2	-5	+2

1

$\boxed{(+6\hat{i} \quad -8\hat{j} \quad +1k)\ m/s}$

2



$\cancel{\frac{1}{2}(2+4)3}$

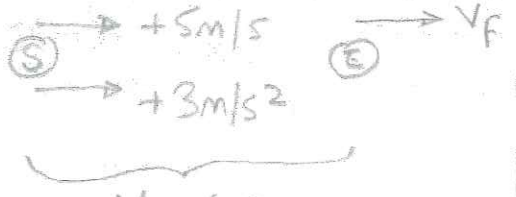
$\cancel{\frac{1}{2}(1+3)1}$

$\frac{1}{2}(2+4)\cdot 2 + 4 = 10\,m$

48 3 Constant acceleration Assignments

Kinematic Equations

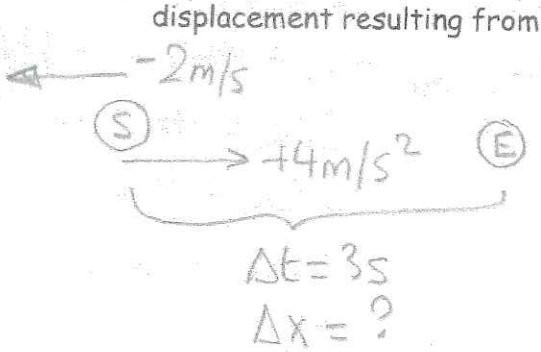
1) A particle had an initial velocity of +5m/s and a constant acceleration of +3m/s^2 throughout its journey. Its journey lasts 4s. What is its final velocity?



$V_i = +5m/s$
$a = +3m/s^2$
$\Delta t = 4s$
$V_f = ?$

$V_f = V_i + a\Delta t$
$V_f = (+5) + (+3)(4)$
$V_f = (+5) + (+12)$
$\boxed{V_f = +17m/s}$

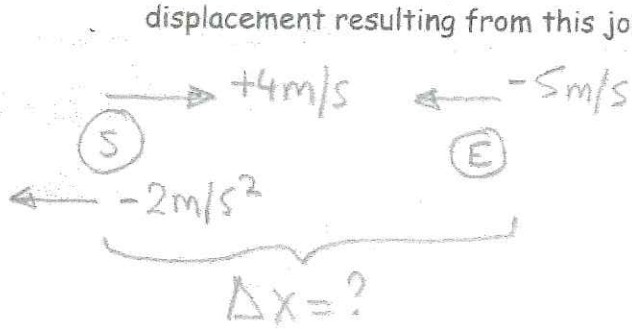
2) A particle has a constant acceleration of +4m/s^2 throughout its journey. The journey lasts for 3s. The particle's initial velocity is -2m/s. What is the particles displacement resulting from this journey?



$V_i = -2m/s$
$a = +4m/s^2$
$\Delta t = 3s$
$\Delta x = ?$

$\Delta x = V_i \Delta t + \frac{1}{2} a \Delta t^2$
$\Delta x = (-2)(3) + \frac{1}{2}(+4)(3^2)$
$\Delta x = (-6) + (+18)$
$\boxed{\Delta x = +12m}$

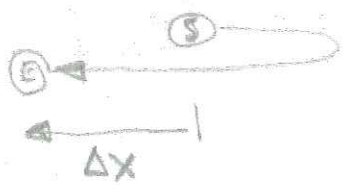
3) A particle had an initial velocity of +4m/s and a constant acceleration of -2m/s^2 throughout its journey. Its final velocity was -5m/s. What is the particles displacement resulting from this journey?



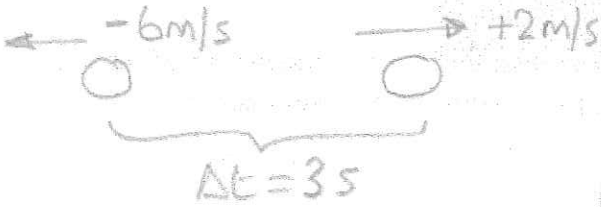
$V_i = +4m/s$
$a = -2m/s^2$
$V_f = -5m/s$
$\Delta x = ?$

$V_f^2 = V_i^2 + 2a\Delta x$
$(-5)^2 = (+4)^2 + 2(-2)\Delta x$
$25 = 16 - 4\Delta x$
$\Delta x = \frac{16 - 25}{4} = \frac{-9}{4}$
$\boxed{\Delta x = -2.25m}$

actually the motion is like this



4) A particle has an initial velocity of -6m/s. It has a final velocity of +2m/s. Its journey was at constant acceleration and lasted 3s. What displacement resulted from this journey?

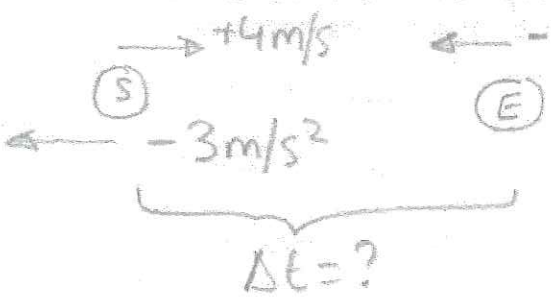


$v_i = -6\,m/s$
$v_f = +2\,m/s$
$\Delta t = 3s$
$\Delta x = ?$

$\Delta x = \frac{1}{2}(v_f + v_i)\Delta t$
$\Delta x = \frac{1}{2}((+2)+(-6))3$
$\Delta x = \frac{1}{2}(-4)3$

$\boxed{\Delta x = -6\,m}$

5) A particle had an initial velocity of +4m/s and a constant acceleration of -3m/s^2 throughout its journey. Its final velocity is -2m/s. How long did the journey last?

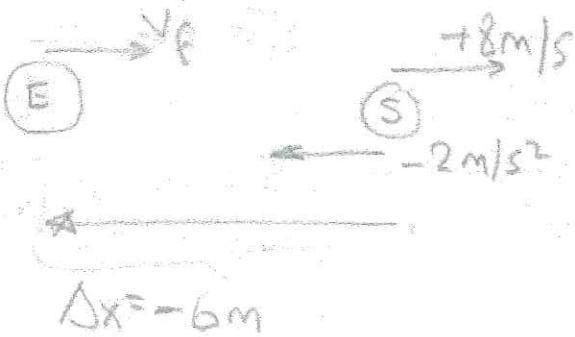


$v_i = +4\,m/s$
$a = -3\,m/s^2$
$v_f = -2\,m/s$
$\Delta t = ?$

$v_f = v_i + a\Delta t$
$(-2) = (+4) + (-3)\Delta t$
$3\Delta t = 4 + 2$
$3\Delta t = +6$

$\boxed{\Delta t = 2\,s}$

6) A particle had an initial velocity of +8m/s and a constant acceleration of -2m/s^2 throughout its journey. Its journey causes a displacement of -6m. What is its final velocity?



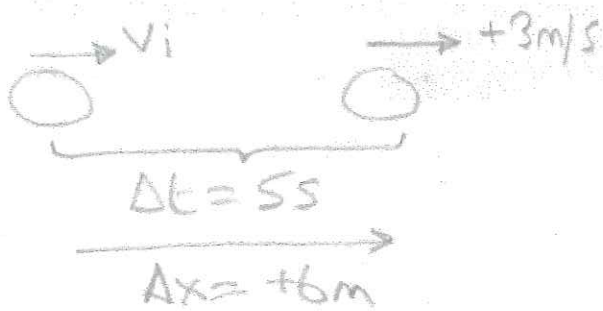
$v_i = +8\,m/s$
$a = -2\,m/s^2$
$v_f = ?$
$\Delta x = -6\,m$

$v_f^2 = v_i^2 + 2a\Delta x$
$v_f^2 = (+8)^2 + 2(-2)(-6)$
$v_f^2 = 64 + 24$
$v_f^2 = 88$

$v_f = \pm\sqrt{88} = \pm 9.4\,m/s$

FROM DIAGRAM IT IS CLEAR THAT $\boxed{v_f = -9.4\,m/s}$

7) A particle has a final velocity of +3m/s. Its journey was at constant acceleration and lasted 5s. The journey causes a displacement of +6m. What was its initial velocity?



$V_i = ?$
$V_f = +3m/s$
$\Delta t = 5$
$\Delta x = +6m$

$\Delta x = \frac{1}{2}(v_f + v_i)\Delta t$

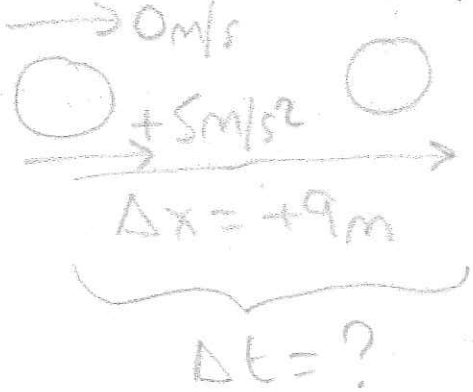
$(+6) = \frac{1}{2}((+3) + v_i)5$

$\frac{(+6)(2)}{(+5)} = (+3) + v_i$

$v_i = \frac{12}{5} - 3 = 2.4 - 3$

$\boxed{V_i = -0.6 m/s}$

8) A particle has a constant acceleration of +5m/s² throughout its journey. The particle's initial velocity is 0m/s. The particles displacement resulting from this journey is +9m. That was the duration of the journey?



$V_i = 0m/s$
$a = +5m/s^2$
$\Delta x = +9m$
$\Delta t = ?$

$\Delta x = v_i \Delta t + \frac{1}{2} a \Delta t^2$

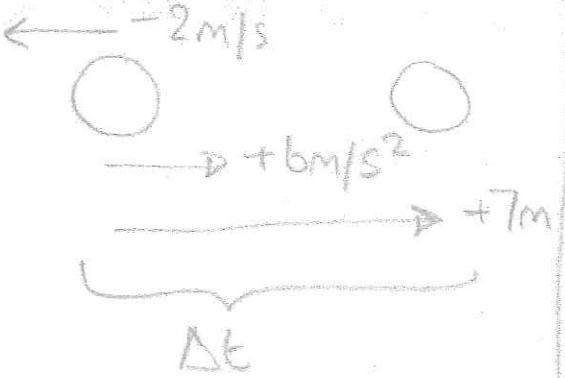
$+9 = (0)\Delta t + \frac{1}{2}(+5)\Delta t^2$

$+9 = +\frac{5}{2}\Delta t^2$

$\Delta t^2 = \frac{+18}{5} = +3.6$

$\Delta t = \pm\sqrt{3.6} = \boxed{\pm 1.897s}$

9) A particle has a constant acceleration of +6m/s² throughout its journey. The particle's initial velocity is -2m/s. The particles displacement resulting from this journey is +7m. That was the duration of the journey?



$V_i = -2m/s$
$a = +6m/s^2$
$\Delta x = +7$
$\Delta t = ?$

$\Delta x = v_i \Delta t + \frac{1}{2} a \Delta t^2$

$+7 = (-2)\Delta t + \frac{1}{2}(+6)(\Delta t^2)$

$+7 = -2\Delta t + 3\Delta t^2$

$0 = 3\Delta t^2 - 2\Delta t - 7$

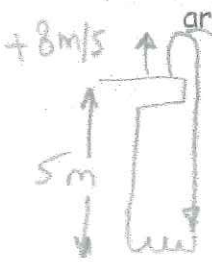
Solve using $x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$

$\Delta t = \frac{-(-2) \pm \sqrt{4 - 4(3)(-7)}}{2(3)} = \frac{+2 \pm \sqrt{88}}{6}$

$\boxed{\Delta t = +1.896 m/s \text{ or } -1.23 m/s}$

Free-fall

10) A diver jumps upwards off a diving board with a speed of 8m/s. The board is 5m above the water. What is the diver's acceleration when she is stationary at the top of her ark?

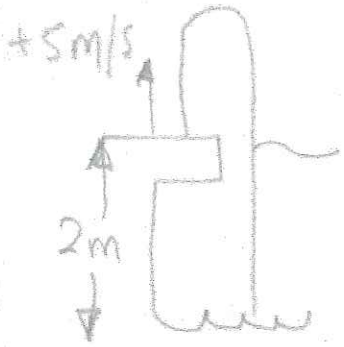


acceleration is constant during free fall

acceleration is $\boxed{-10\ m/s^2}$

(Conceptual question)

11) A diver jumps upwards off a diving board with a speed of 5m/s. The board is 2m above the water. What is the diver's acceleration when she passes the board on her way downwards towards the water?

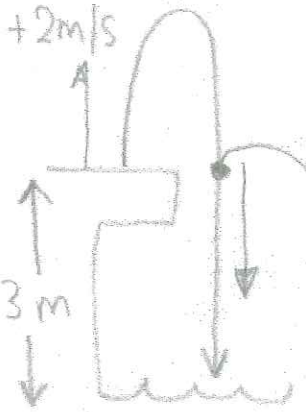


acceleration is constant during free fall

acceleration is $\boxed{-10\ m/s^2}$

(Conceptual question)

12) A diver jumps upwards off a diving board with a speed of 2m/s. The board is 3m above the water. What is the diver's velocity when she passes the board on her way downwards towards the water?

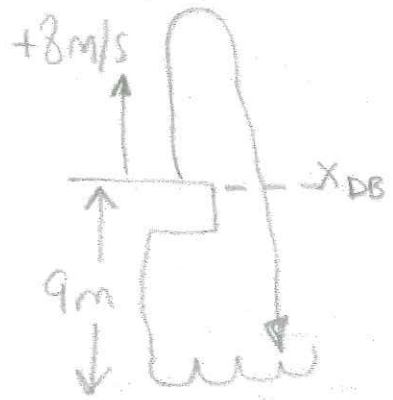


Speed is equal at points at the same height in free fall.

So velocity is $\boxed{-2m/s}$

(Conceptual question)

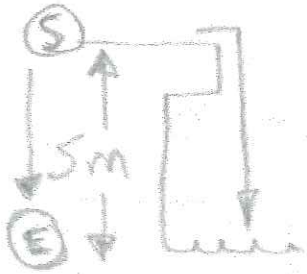
13) A diver jumps upwards off a diving board with a speed of 8m/s. The board is 9m above the water. What is the diver's displacement from the board when she passes the board on her way downwards towards the water?



$\Delta x = x_f - x_i = x_{DB} - x_{DB} = \boxed{0\,m}$

(Conceptual question)

14) A diver steps off of a diving board. The diving board is 5m above the water. How long does it take the diver to reach the water?

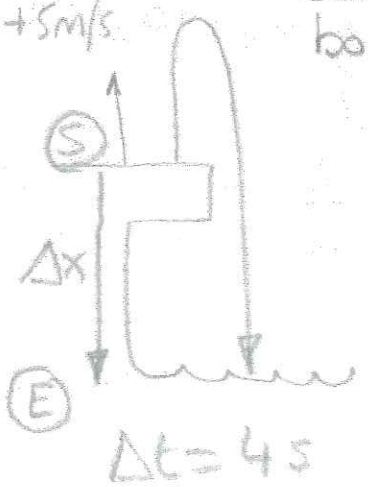


$v_i = 0\ m/s$
$a = -10\ m/s^2$
$\Delta x = -5m$
$\Delta t = ?$

$\Delta x = v_i \Delta t + \frac{1}{2} a \Delta t^2$
$-5 = (0)\Delta t + \frac{1}{2}(-10)\Delta t^2$
$-5 = -5\Delta t^2$
$\Delta t^2 = 1$
$\Delta t = \sqrt{1} = \pm 1s \rightarrow \boxed{+1s}$

15) A diver jumps up off of a diving board at +5m/s. The diver takes 4s to reach the water below the board. How high is the diving board above the water?

If we start on the board, and end at the water, the displacement is the same as the height of the board.

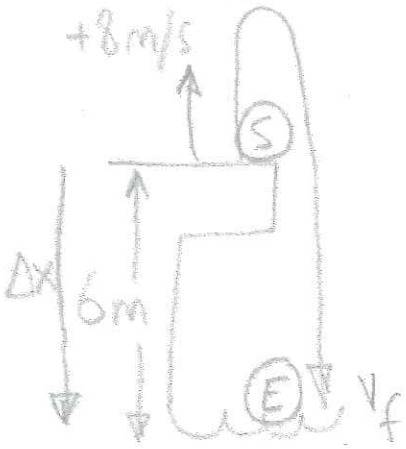


$v_i = +5m/s$
$a = -10\ m/s^2$
$\Delta x = ?$
$\Delta t = 4s$

$\Delta x = v_i \Delta t + \frac{1}{2} a \Delta t^2$
$\Delta x = (+5)(4) + \frac{1}{2}(-10)(4^2)$
$\Delta x = 20 - 80 = -60m$

$\boxed{\text{height is } 60m}$

16) A diver jumps upwards off of a diving board with a speed of 8m/s. The board is 6m above the water. What is the diver's speed as she reaches the water?



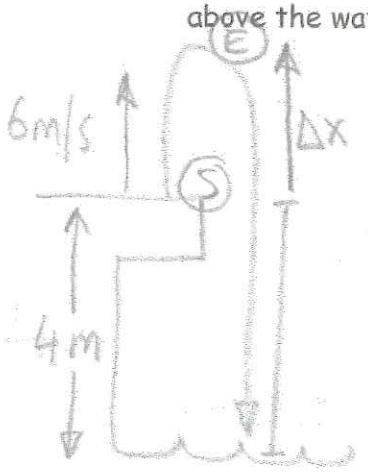
$v_i = +8\,m/s$
$a = -10\,m/s^2$
$\Delta x = -6\,m$
$v_f = ?$

$v_f^2 = v_i^2 + 2a\Delta x$
$v_f^2 = (+8)^2 + 2(-10)(-6)$
$v_f^2 = 64 + 120 = 184$

$v_f = \sqrt{184} = \pm 13.56\,m/s$

by observation $\boxed{v_f = -13.56\,m/s}$

17) A diver jumps upwards off of a diving board with a speed of 6m/s. The board is 4m above the water. What is the diver's maximum height above the water?

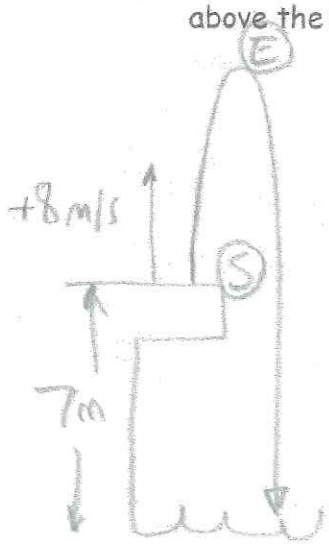


$v_i = 6\,m/s$
$a = -10\,m/s^2$
$\Delta x = ?$
$v_f = 0\,m/s$

$v_f^2 = v_i^2 + 2a\Delta x$
$0^2 = (+6^2) + 2(-10)(\Delta x)$
$0 = 36 - 20\Delta x$
$\Delta x = +\frac{36}{20} = +1.8\,m$

so height above water is $\Delta x + 4m = 1.8m + 4m = \boxed{+5.8m}$

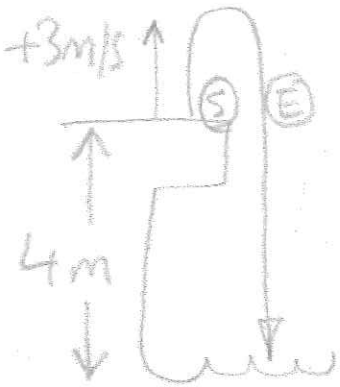
18) A diver jumps upwards off of a diving board with a speed of 8m/s. The board is 7m above the water. For what duration of time does the diver travel upwards?



$v_i = +8\,m/s$
$a = -10\,m/s^2$
$v_f = 0\,m/s$
$\Delta t = ?$

$v_f = v_i + a\Delta t$
$(0) = (+8) + (-10)(\Delta t)$
$10\Delta t = 8$
$\Delta t = \frac{8}{10} = \boxed{0.8\,s}$

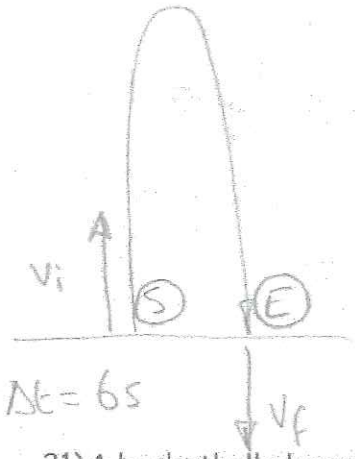
19) A diver jumps upwards off of a diving board with a speed of 3m/s. The board is 4m above the water. How long does it take the diver to pass the board on her way downwards towards the water?



$v_i = +3\,m/s$
$v_f = -3\,m/s$
$a = -10\,m/s^2$
$\Delta t = ?$

$v_f = v_i + a\Delta t$
$(-3) = (+3) + (-10)(\Delta t)$
$\Delta t = \frac{-6}{-10} = \boxed{0.6\,s}$

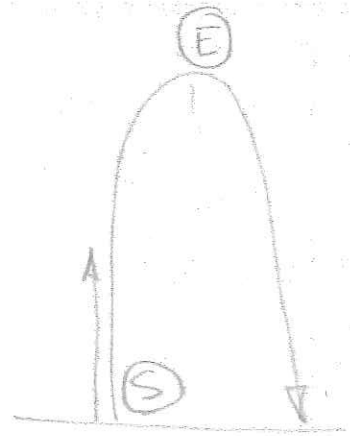
20) A basketball player jumps upward from a gym floor. Her hang-time (time in the air) is 6s. What was her initial velocity?



$v_i = ?$
$a = -10\,m/s$
$\Delta t = 6s$
$\Delta x = 0\,m$

$\Delta x = v_i \Delta t + \frac{1}{2} a \Delta t^2$
$0 = v_i(6) + \frac{1}{2}(-10)(6^2)$
$0 = 6v_i - 180$
$v_i = \frac{180}{6} = \boxed{+30\,m/s}$

21) A basketball player jumps upwards from a gym floor. Her hang-time is 4s. What was her maximum height above the floor?



$\Delta t = 4s$

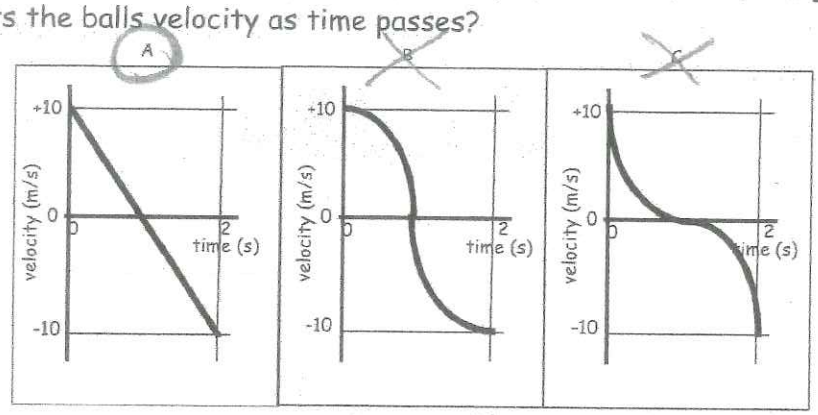
$v_f = 0\,m/s$
$a = -10\,m/s^2$
$\Delta t = \frac{4}{2}\,s$
$\Delta x = ?$

$\Delta x = v_i \Delta t + \frac{1}{2} a \Delta t^2$
$\Delta x = v_i\left(\frac{4}{2}\right) + \frac{1}{2}(-10)\left(\frac{4}{2}\right)^2$
$\Delta x = 2v_i - 20$

$v_f = v_i + a\Delta t$
$0 = v_i + (-10)\left(\frac{4}{2}\right)$
$v_i = 20\,m/s$

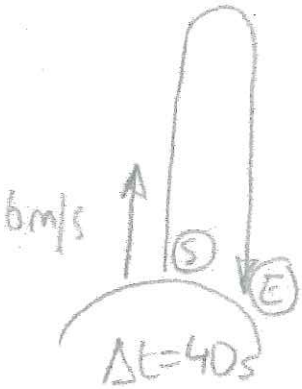
$\Delta x = 2(+20) - 20 = \boxed{20m}$

22) A tennis player throws a ball upwards with a speed of 10m/s. Which graph best represents the balls velocity as time passes?



velocity changes linearly with time because a is constant

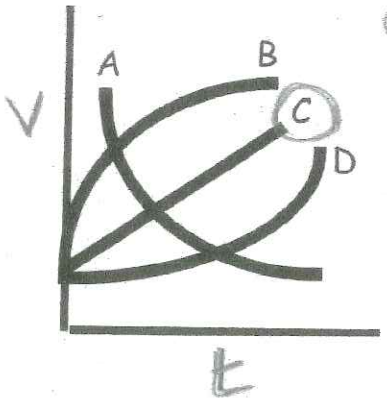
23) An astronaut is on the surface of an asteroid. She jumps upwards with a speed of 6m/s. Her hang-time is 40s. What is the acceleration caused by gravity?



$V_i = +6 m/s$
$V_f = -6 m/s$
$\Delta x = 0 m$
$\Delta t = 40 s$
$a = ?$

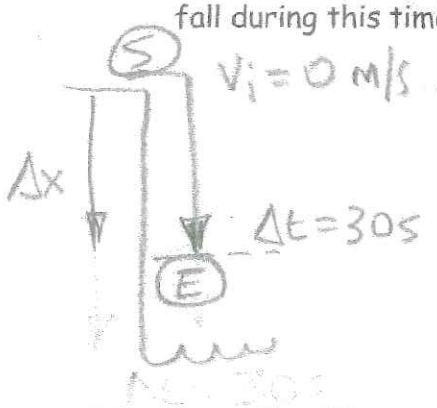
$V_f = V_i + a\,\Delta t$
$(-6) = (+6) + (a)(40)$
$-12 = 40a$
$a = \frac{-12}{40} = \boxed{-0.3 m/s^2}$

24) A car is travelling in a positive direction along a straight and level road. At a certain time the car starts to move with a constant positive acceleration. Which trace best represents the resulting velocity versus time graph for the constant acceleration part of the journey?



Constant acceleration is linear trace in V vs t graph

25) In the movie "Superman II", a small child falls over Niagara Falls. The film shows that the child falls for 30 seconds before Superman catches him. How far does the child fall during this time?



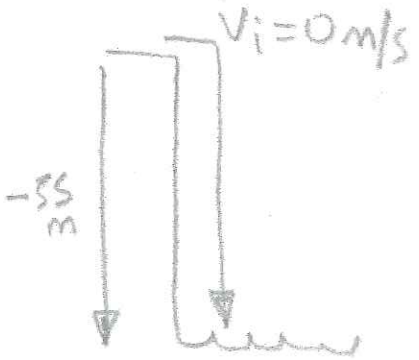
$V_i = 0$ m/s
$a = -10$ m/s^2
$\Delta t = 30$s
$\Delta x = ?$

$\Delta x = V_i \Delta t + \frac{1}{2} a \Delta t^2$

$\Delta x = (0)(30) + \frac{1}{2}(-10)(30^2)$

$\boxed{\Delta x = -4500 \text{ m}}$

26) In reality, Niagara Falls is 55 m tall. In the movie "Superman II" a small child falls over the falls. How long would Superman have to catch the child before he reached the water?



$V_i = 0$ m/s
$a = -10$ m/s^2
$\Delta t = ?$
$\Delta x = -55$ m

$\Delta x = V_i \Delta t + \frac{1}{2} a \Delta t^2$

$(-55) = (0)(\Delta t) + \frac{1}{2}(-10)\Delta t^2$

$-55 = -5 \Delta t^2$

$\Delta t^2 = +11$

$\Delta t = \sqrt{11} = \pm 3.316$ s

$\boxed{\Delta t = 3.316 \text{ s}}$