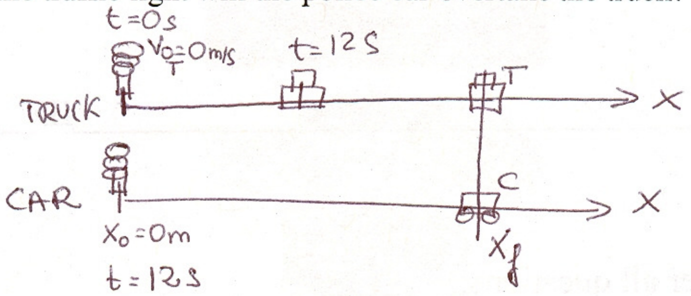
1. A truck, initially at rest at a traffic light, speeds up with a constant acceleration $a = 0.4$ m/s^2. A police car passes the same traffic light 12 s after the truck departed. If the police car is traveling at a constant speed of 30 m/s:

(a) How long does the police car need to overtake the truck? *(10 points)*
(b) How far from the traffic light will the police car overtake the truck? *(10 points)*

$a_T = 0.4\ m/s^2$
$V_C = 30 m/s$



TRUCK : $x_f - \cancel{x_0} = \cancel{V_{0T}} t + \frac{1}{2} a_T t^2 \Rightarrow \boxed{x_f = \frac{1}{2} a_T t^2}$ (1)

CAR : $x_f - \cancel{x_0} = V_C \cdot (t - 12) \Rightarrow \boxed{x_f = V_C \cdot (t-12)}$ (2)

$(1) = (2) \Rightarrow \frac{1}{2} a_T t^2 = V_c (t-12) \Rightarrow \frac{1}{2} a_T t^2 - V_c t + 12 V_c = 0$

$\Rightarrow \boxed{t = 13.15\ s}$

(a) $t_{police} = 13.15 s - 12 s = \boxed{1.15\ s}$

(b) $x_f = V_c (t - 12) = (30 m/s) \cdot (1.15 s) = \boxed{34.5\ m}$

(a) 1.15s	s	(b) 34.5	m

2. (a) The movement of an object is described by the following equation: $x(t) = -t + 2t^3$, where t is in seconds and x in meters. Calculate:

(i) The average velocity from t = 1 s to t = 5 s. *(5 points)*
(ii) The acceleration of the car at t = 2 s. *(5 points)*

(i) $V_{avg} = \dfrac{x(5)-x(1)}{5s - 1s} = \dfrac{245m - 1m}{4s} = \boxed{61\ m/s}$

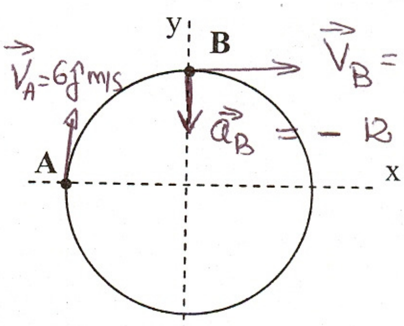
$x(5) = -5 + 250\ m = 245\ m$
$x(1) = -1 + 2 = 1\ m$

(ii) $v(t) = \dfrac{dx}{dt} = -1 + 6t^2 \rightarrow a(t) = \dfrac{dv(t)}{dt} = 12t$

$\boxed{a(2) = 24\ m/s^2}$

(b) A particle moves with constant speed around the circle below. When it is at point A its coordinates are x = -3 m, y = 0 m and its velocity is 6 $\hat{j}$ m/s. Obtain its velocity and acceleration at point B. (Express your answer in terms of unit vectors). *(10 points)*

$a_B = \dfrac{V^2}{R} = \dfrac{36\ m^2/s^2}{3\ \cancel{m}} = 12\ m/s^2$
Centripetal



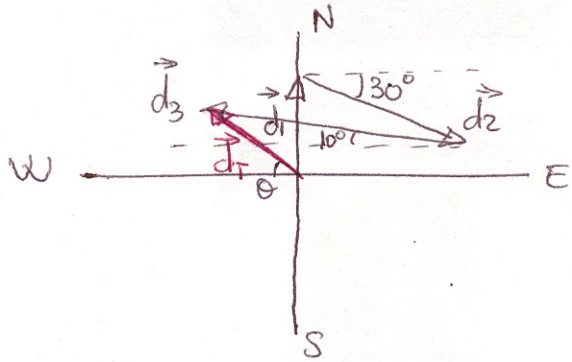
$\vec{V}_B = 6\hat{i}\ m/s$

$\vec{a}_B = -12\hat{j}\ m/s^2$

(a)(i) 61	m/s	(a) (ii) 24	m/s^2	(b) $\vec{V}_B = 6\hat{i}\ m/s$ / $\vec{a}_B = -12\hat{j}\ m/s^2$	

3. A hiker makes three consecutive displacements across a dense forest starting from his campsite. The first displacement is 5 km due North, the second one 3 km 30° South of East, and the third one 7 km 10° North of West. Find:

(a) How far from its original position will the hiker end? *(10 points)*
(b) In which direction should he walk to go back to his campsite? *(10 points)*



$\boxed{\vec{d_1} = 5\hat{j} \text{ Km}}$

$\vec{d_2} = (3\cos 30^\circ \hat{i} - 3\sin 30^\circ \hat{j})\text{ Km}$

$\boxed{\vec{d_2} = 2.60\hat{i} - 1.5\hat{j} \text{ Km}}$

$\vec{d_3} = (-7\cos 10^\circ \hat{i} + 7\sin 10^\circ \hat{j})\text{ Km}$

$\boxed{\vec{d_3} = (-6.9\hat{i} + 1.2\hat{j}) \text{ Km}}$

(a) $\vec{d_T} = \vec{d_1} + \vec{d_2} + \vec{d_3} = (-4.3\hat{i} + 4.7\hat{j})$ Km

$|\vec{d_T}| = \sqrt{4.3^2 + 4.7^2} = \boxed{6.37 \text{ Km}}$

(b) $\tan\theta = \frac{d_{Ty}}{d_{Tx}} = \frac{4.7}{4.3} \Rightarrow \theta = +47.5^\circ$

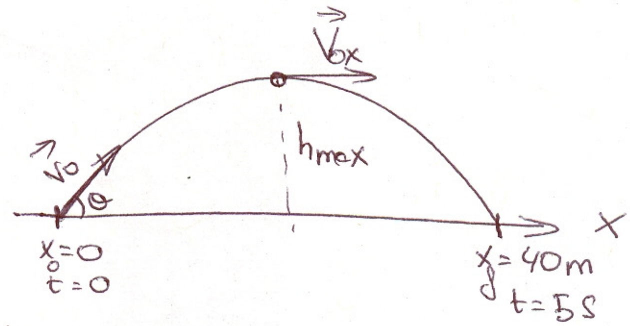
Direction:

To go back to campsite $\Rightarrow$ 47.5° South of East

(a) 6.37	Km	(b) 47.5° South of East	

4. A projectile fired into the air from ground level lands 40 m away from the launching position 5 s later. Neglecting air resistance, find:

(a) Direction of the initial velocity. *(5 points)*
(b) Magnitude of the initial velocity. *(5 points)*
(c) Maximum height reached by the projectile during its flight. *(10 points)*



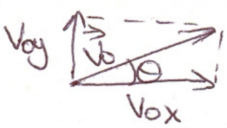
(b)

$x_f - x_o = 40m = V_o \cos\theta \cdot t = V_{ox} \cdot t \Rightarrow V_{ox} = \frac{40m}{5s} = \boxed{8 m/s}$

$\cancel{y_f}^{0} - \cancel{y_o}^{0} = V_{oy} \cdot t - \frac{1}{2} g t^2 \Rightarrow 0 = V_{oy} \cdot (5s) - (4.9 \frac{m}{s^2}) \cdot (25 s^2) \Rightarrow \boxed{V_{oy} = 24.5 \, m/s}$

$|\vec{V}_o| = \sqrt{V_{ox}^2 + V_{oy}^2} = \sqrt{(8 m/s)^2 + (24.5 m/s)^2} = \boxed{25.8 \, m/s}$

(a) $\tan\theta = \frac{V_{oy}}{V_{ox}} = \frac{24.5 \, m/s}{8 \, m/s} \Rightarrow \boxed{\theta \simeq 72°}$



(c) $h_{max} \rightarrow V_{y(h_{max})} = 0$; $a_y = -g = -9.8 m/s^2$

$a_y = \frac{\cancel{V_{y(h_{max})}} - V_{oy}}{t_{h_{max}}} \Rightarrow t_{h_{max}} = \frac{\cancel{-}V_{oy}}{\cancel{-}g} = \frac{24.5 m/s}{9.8 m/s^2} = \boxed{2.5 s}$

$h_{max} - \overset{y_o}{0} = V_{oy} \cdot t_{h_{max}} - \frac{1}{2} g t_{h_{max}}^2 = (24.5 m/s)(2.5 s) - (4.9 \frac{m}{s^2}) \cdot (2.5 s)^2 =$

$\boxed{h_{max} = 30.62 m}$

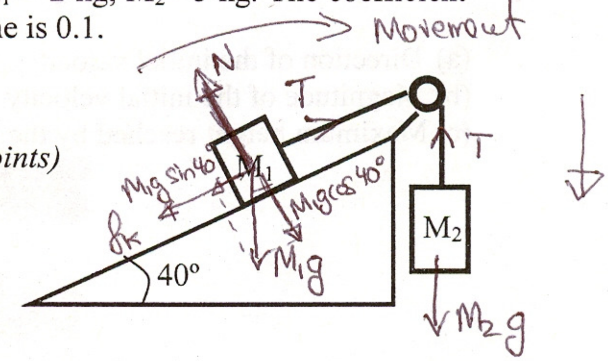
(a) 72 °	(b) 25.8 m/s	(c) 30.62 m

5. The two blocks in the diagram below are connected by a massless cord to a massless pulley. The masses of the blocks are: $M_1 = 2$ kg, $M_2 = 5$ kg. The coefficient of kinetic friction between M_1 and the incline plane is 0.1.

(a) Draw the force diagram. *(4 points)*

(b) Calculate the acceleration of the system. *(8 points)*

(c) Obtain the tension on the cord. *(8 points)*



(b) M_2 $\Rightarrow$ $\boxed{M_2 g - T = M_2 a}$ (1)

M_1 $\Rightarrow$
$$\begin{cases} T - f_K - M_1 g \sin 40° = M_1 a \\ N - M_1 g \cos 40° = 0 \\ f_K = \mu_K \cdot N = \mu_K \cdot M_1 g \cos 40° \end{cases}$$

$\Rightarrow$ $\boxed{T - \mu_K M_1 g \cos 40° - M_1 g \sin 40° = M_1 a}$ (2)

Adding (1) + (2) $\quad M_2 g - \mu_K M_1 g \cos 40° - M_1 g \sin 40° = (M_1 + M_2) a$

$\Rightarrow$ $\boxed{a = 4.98 \text{ m/s}^2}$

(c) $T = M_2 (g - a) = (5 \text{kg})(9.8 \text{m/s}^2 - 4.98 \text{m/s}^2) = \boxed{24 \text{ N}}$

(b) 4.98 m/s2	(c) $\boxed{T = 24 N}$