MIDTERM 1
2009 SUMMER

Solve the following problems

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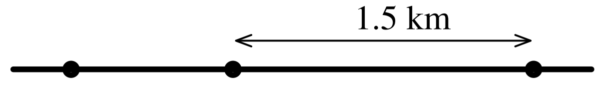
1. A car starts from rest to move from point A to point B with constant acceleration. It arrives to B after 25 s with a velocity of 30 m/s. It moves further from B toward point C with unchanged velocity (30 m/s). **Calculate the average velocity of the car (in m/s) during its way form A to C**.



$$\bar{v} = \frac{\Delta x_1 + \Delta x_2}{\Delta t_1 + \Delta t_2} = \frac{\bar{v}\ \Delta t_1 + \Delta x_1}{\Delta t_1 + \Delta x_1 / v_2} = \frac{15m/s \cdot 25s + 1500m}{25s + 1500m/30m/s} = 25m/s$$

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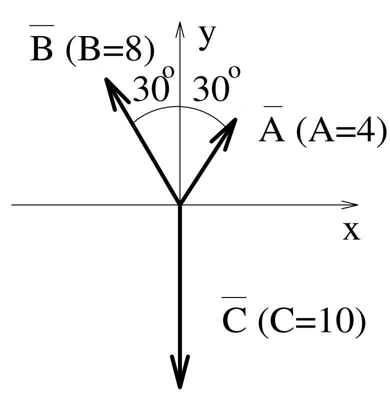
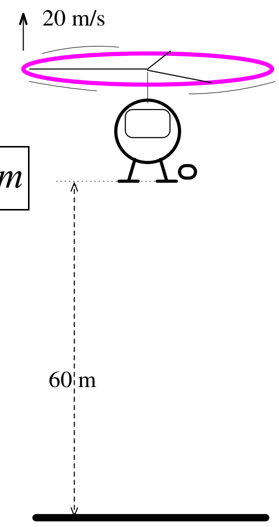
2. Three vectors $\bar{A}, \bar{B}$, and $\bar{C}$ are shown in the figure. Find the **magnitude and direction of the sum vector** $\bar{D} = \bar{A} + \bar{B} + \bar{C}$ **.**



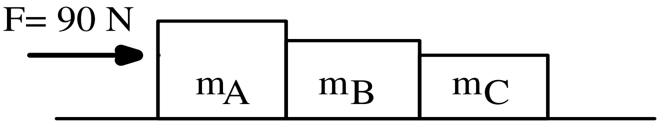
$$A_x = 4\cos 60 = 2; \qquad A_y = 4\sin 60 = 3.46$$
$$B_x = 8\cos 120 = -4; \qquad B_y = 8\sin 120 = 6.928$$
$$C_x = 10\cos 270 = 0 \qquad C_y = 10\sin 270 = -10$$
$$D_x = 2 - 4 + 0 = -2$$
$$D_y = 3.46 + 6.928 - 10 = 0.388$$
$$D = \sqrt{D_x^2 + D_y^2} = 2.037$$
$$\theta = \tan^{-1}\frac{D_y}{D_x} = -11^o$$
$$\theta = 180^o + \tan^{-1}\frac{D_y}{D_x} = 180^o + (-11^o) = 169^o$$

3. A helicopter is ascending at a constant velocity 20 m/s, as shown. At a height of 60 m a package is dropped from the helicopter. **Find the distance between the helicopter and the package 4s after the package is released.**



$$\Delta\ y = \Delta\ y_{helic} - \Delta\ y_{stone} = +(v_0 t) - (v_0 t + at^2/2) = 20m/s \cdot 4s - 0 = 80m$$

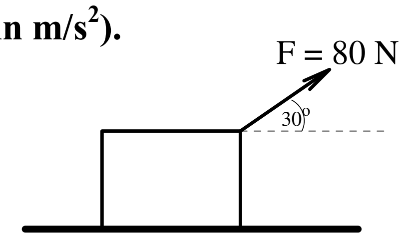
4. Three masses $\mathbf{m_A}$= 8 kg, $\mathbf{m_B}$= 6 kg, and $\mathbf{m_C}$= 4 kg are in contact on a frictionless table. A horizontal force is applied on $\mathbf{m_A}$, as shown in the figure. **Find the net force (in N) acting of $\mathbf{m_B}$.**



The masses can be treated as one mass of 18 kg, so

$$F = ma \rightarrow a = \frac{F}{m} = \frac{90N}{18kg} = 5m/s \Rightarrow\Rightarrow F_B = m_B a = 6kg \cdot 5m/s = 30N$$

5. A 12-kg box is pulled with a 80-N force as shown in the figure. The kinetic friction coefficient is μ_k= 0.3. **Calculate the acceleration of the box (in m/s^2).**



$$F_y^{net}: \quad F_N + F_p \sin 30 - mg = 0 \Rightarrow F_N = mg - F_p \sin 30 = 120N - 40N = 80N$$

$$F_x^{net}: \quad F_p \cos 30 - F_{fr} = F_p \cos 30 - \mu F_N = 69.28N - 0.3 \cdot 80N = 45.28N = ma$$

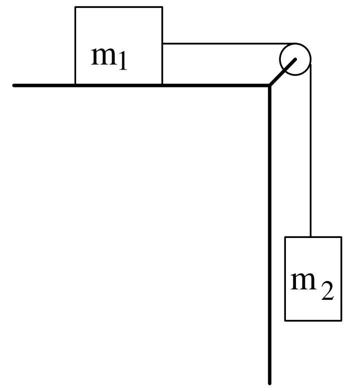
$$\Rightarrow a = \frac{45.28N}{12kg} = 3.77m/s^2$$

6. Two masses $\mathbf{m_1}$= 4 kg and $\mathbf{m_2}$= 6 kg are connected via a massless cord and pulley. $\mathbf{m_1}$ moves on a frictionless table. **Find the acceleration of $\mathbf{m_1}$ (in m/s^2)**.

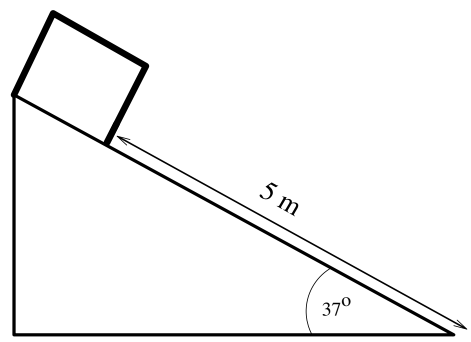
m_1: $T = m_1 a$ (1)

m_2: $-T + m_2 g = m_2 a$ (2)

(1)+(2): $m_2 g = (m_1 + m_2)a \Rightarrow a = \frac{m_2 g}{m_1 + m_2} = 6 m/s^2$



7. A box of mass m = 15 kg starting from rest slides down along the 5 m long incline. **Calculate the velocity at which the box reaches the bottom of the incline (in m/s).** The kinetic friction coefficient between the box and the incline is $\mu_k = 0.3$.



$a = g\sin 37 - \mu g \cos 37 = 3.6 m/s^2 \Rightarrow$

$v^2 = v_0^2 + 2a\Delta x \Rightarrow v = \sqrt{2a\Delta x} = 6 m/s$

8. A mass of 3 kg is in uniform circular motion around a horizontal circle of radius R = 3 m. It makes 20 full rotations in 1 minute. **Find the magnitude of net force (in N) that keeps the body in circular motion.**

$T = 60s/20 = 3s$

$F = ma = m\frac{v^2}{R} = m\frac{(2\pi R)^2}{T^2 R} = 39.5N$