Name:

In order to get full credit for your work please show all your work, and explain reasoning clearly where necessary.

1. A boy pulls a box of mass 30 kg with a force of 25 N in the direction shown in Figure 1. What is the normal force exerted on the box by the ground? (5.0 points)

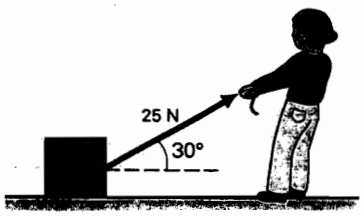
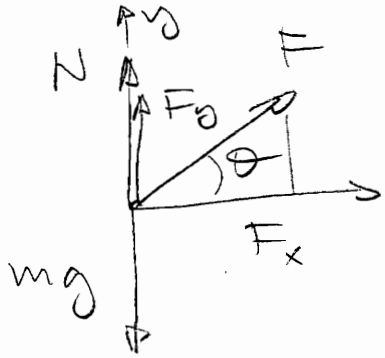


Figure 1



$F = 25\ N$

$m = 30\ kg$

$\theta = 30.0°$

$F_y = F \sin\theta$

$F_x = F \cos\theta$

$\sum F_y = N + F_y - mg = 0 \quad N = mg - F_y$

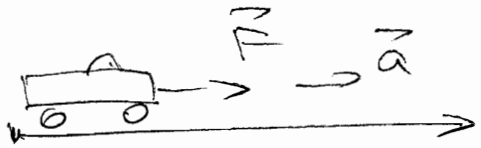
$N = mg - F\sin 30° = 30\ 9.81 - 25 \sin 30°$

$N = 281.8\ N = 280\ N$

2. To determine the mass of a car, a student (with a friend at the wheel) pushes the car holding a bathroom scale between himself and the car and carefully maintains a constant reading of 400 N on the scale while the car accelerates on level ground. At the conclusion of the experiment his friend reports that the car accelerated from rest to 14.0 km/hr in 12.0 s. What was the mass of the car? (5.0 points)

$V_0 = 0 \quad V = 14.0 \frac{km}{h} = \frac{14{,}000\ m}{3600\ s} = 3.89 \frac{m}{s}$

$V = V_0 + at \quad a = \frac{V}{t} = \frac{3.89}{12} = 0.324 \frac{m}{s^2}$



$F = 400\ N$

$F = ma \quad m = \frac{F}{a} = \frac{400}{0.324}$

$m = 1{,}230\ kg$

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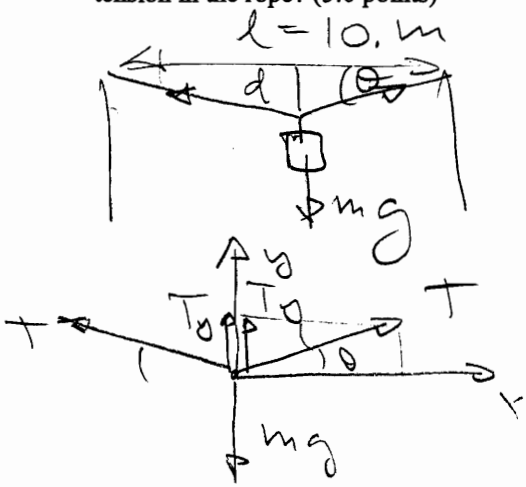
3. A rope is fixed at both ends on two trees, and a bag is hung in the middle of the rope, causing the rope to sag vertically. If the tree separation is 10 m, the mass of the bag is 5.0 kg, and the sag is 0.20 m, what is the tension in the rope? (5.0 points)



$l = 10\ m \quad m = 5.0\ kg$

$d = 0.20\ m$

$\theta = \tan^{-1}\frac{d}{l/2} = \tan^{-1}\frac{0.20}{5.0}$

$\theta = 2.29°$

$\Sigma F_y = 2T_y - mg = 0$

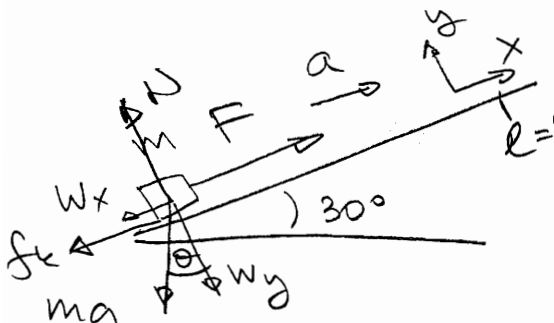
$2T\sin\theta = mg$

$T_y = T\sin\theta$

$T = \frac{mg}{2\sin\theta} = \frac{5.0\ 9.81}{2\sin 2.29°}$

$T = \frac{49.05}{0.079a} = 614\ N = 610N$

4. A 2.0-kg block is pulled up a ramp by a constant force parallel to the ramp of 15 N. The ramp is 2.0 m long and inclined at 30° above the horizontal. If the coefficient of kinetic friction between the block and the ramp is 0.30, what is the speed of the block at the top of the ramp? (5.0 points)



$W_x = mg\sin\theta \quad W_y = mg\cos\theta \quad m = 2.0$

$F = 15\ N \quad l = 2.0\ m \quad \theta = 30° \quad \mu_k = 0.3$

$\Sigma F_y = N - W_y = 0 \quad N = mg\cos\theta$

$f_k = \mu_k mg\cos\theta \quad v_0 = 0$

$ma = \Sigma F_x = F - f_k - W_x = F - \mu_k mg\cos\theta - mg\sin\theta$

$a = \frac{F - \mu_k mg\cos\theta - mg\sin\theta}{m}$

$a = \frac{15 - 0.30\ 2.0\ 9.81\cos 30° - 2.0\ 9.81\sin\theta}{2.0}$

$a = \frac{15 - 5.097 - 9.81}{2.0} = \frac{0.093}{2.0} = 0.046\ \frac{m}{s^2}$

$v^2 = v_0^2 + 2a\,l = 0 + 2\ 0.046\ 2 = 0.186\ \frac{m^2}{s^2}$

$v = 0.43\ \frac{m}{s}$

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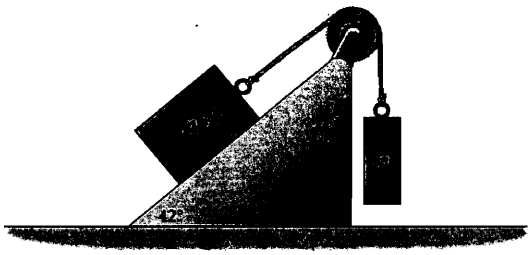
5. Two blocks are connected by a string, as shown in Figure 2. The smooth inclined surface makes an angle of 42" with the horizontal, and the block on the incline has a mass of 6.7 kg. Find the mass of the hanging block that will cause the system to be in equilibrium. (The pulley is assumed to be ideal.)



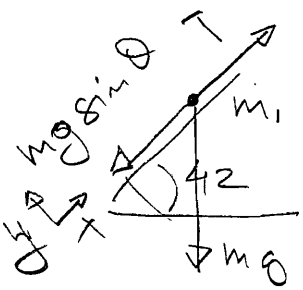


Figure 2

$m_1 = 6.7\ kg \quad \theta = 42°$

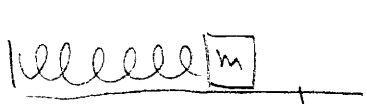
$\Sigma F_x = T - m_1 g \sin\theta = 0 \quad \& \quad \Sigma F_y = T - mg = 0$

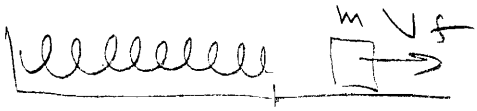
$T = m_1 g \sin\theta \quad T = mg \Rightarrow m_1 g \sin\theta = mg$

$m = m_1 \sin\theta$

$m = 6.7 \sin 42° = 4.5\ kg$

6. A 1.2-kg block is held against a spring of force constant 1.0 x 10^4 N/m, compressing it a distance of 15 cm. How fast is the block moving after it is released and the spring pushes it away? (5.0 point)





$v_i = 0 \quad x_0 = 0$

$v = ?$

$x_i = 0.15\ m$

$k = 1.0\ 10^4\ N/m$

$m = 1.2\ kg$

$E_i = E_f$

$\frac{1}{2} m v_i^2 + \frac{1}{2} k x_i^2 = \frac{1}{2} m v_f^2 + \frac{1}{2} k x_f^2$

$\Rightarrow$

$v_f^2 = \frac{k}{m} x_i^2 \qquad v_f = x_i \sqrt{\frac{k}{m}}$

$v_f = 0.15 \sqrt{\frac{1.0\ 10^4}{1.2}} = 0.15\ 91.29 = 13.69\ m/s$

$v_f = 14\ \frac{m}{s}$

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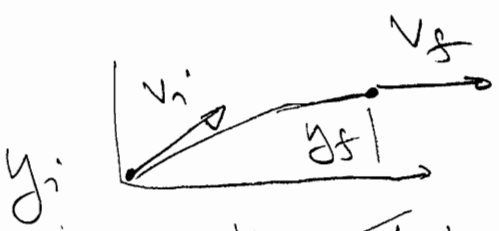
7. A player passes a 0.600-kg basketball down-court for a fast break. The ball leaves the player's hands with a speed of 8.30 m/s and slows down to 7.10 m/s at its highest point. Ignoring air resistance, how high above the release point is the ball when it is at its maximum height? (5.0 points)



$y_i = 0 \quad y_f = ? \quad m = 0.600\ kg$

$v_i = 8.30\ m/s \quad v_f = 7.10\ m/s$

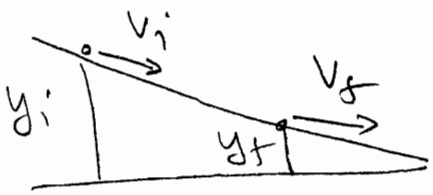
$E_i = E_f$

$mgy_i + \frac{1}{2}mv_i^2 = mgy_f + \frac{1}{2}mv_f^2$

$\Rightarrow y_f = \frac{v_i^2 - v_f^2}{2g} = \frac{8.30^2 - 7.10^2}{2\ 9.81} = \frac{18.48}{19.62}$

$y_f = 0.94\ m$

8. A 15,800-kg truck is moving at 12.0 m/s when it starts down a 6.00° incline in the Canadian Rockies. At the start of the descent the driver notices that the altitude is 1630 m. When she reaches an altitude of 1440 m, her speed is 29.0 m/s. How much nonconservative work is done on the truck? (5.0 points)



$m = 15,800\ kg \quad v_i = 12.0\ m/s \quad y_i = 1,630\ m$

$y_f = 1,440\ m \quad v_f = 29.0\ m/s$

$W_{NC} = E_f - E_i = (mgy_f + \frac{1}{2}mv_f^2) - (mgy_i + \frac{1}{2}mv_i^2)$

$= 15,800\left[(9.81\ 1,440 + \frac{29^2}{2}) - (9.81\ 1,630 + \frac{12^2}{2})\right]$

$= 15,800\left[(14,126 + 420) - (15,990 + 72)\right]$

$= 15,800\ [-1,516] = -23.9\ 10^6\ J$

$W_{NC} = -23.9\ MJ$