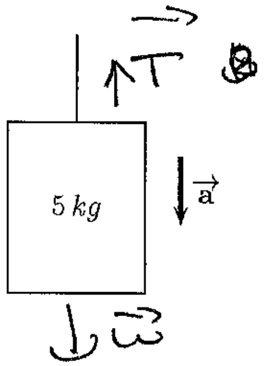
Green

1. A 5.0-kg mass is attached to a massless string which is accelerated downwards at $2.5\,m/s^2$. What is the tension in the string?



(a) 49 N	(b) 12.5 N
(c) 61.5 N	(d) 36.5 N

$\sum F_y = Ma_y$

$\Rightarrow T - W = Ma_y$

$\Rightarrow T = W + Ma_y = Mg + Ma_y = M(g + a_y)$

$\therefore T = 5kg(9.8m/s^2 - 2.5m/s^2) = 5kg(7.3m/s^2) = 36.5N$

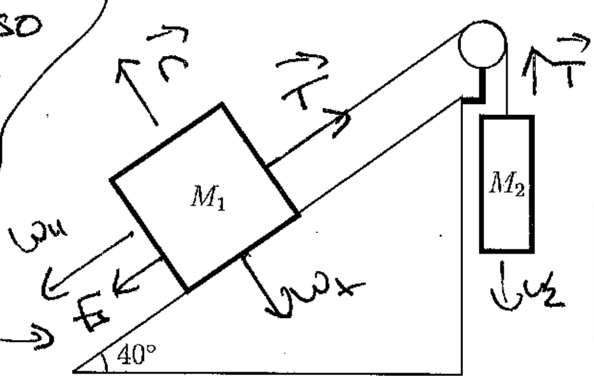
↑ Down is negative

2. A $M_1 = 6.5\,kg$ mass is placed on a 40° incline and then connected by a massless string and over a perfect pulley to another mass, $M_2 = 5.0\,kg$, that is hanging vertically. The coefficient of static friction between M_1 and the incline is $\mu_s = 0.76$. If when released the two masses remain at rest, how much static friction is acting on M_1?

NOTICE: We weren't told $f_s = f_{s,MAX}$ so WE DON'T USE $\mu_s n$

Forces on M_2: $\vec{T}$ up, $\vec{w}_2$ down

M_1: $\vec{T}$ up incline, $w_{\parallel}$, $w_{\perp}$, $\vec{n}$, $\vec{f}_s$



(a) 37.1 N	(b) 8.1 N
(c) 49 N	(d) 40.9 N

$\vec{f}_s$ would be parallel with no friction.

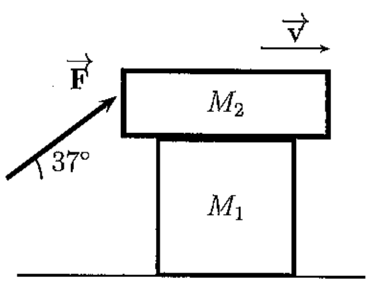
For M_2: $\sum F_{2,y} = M_2 a_{2,y}$. No motion $\Rightarrow a_{2,y} = 0$

$\Rightarrow T - W_2 = 0 \Rightarrow T = W_2 = (5kg)(9.8m/s^2) = 49N$

For M_1: $\sum F_{\parallel} = M_1 a_{\parallel}$. $a_{\parallel} = 0$ too $\Rightarrow T - W_{\parallel} - f_s = 0 \Rightarrow f_s = T - W_{\parallel}$

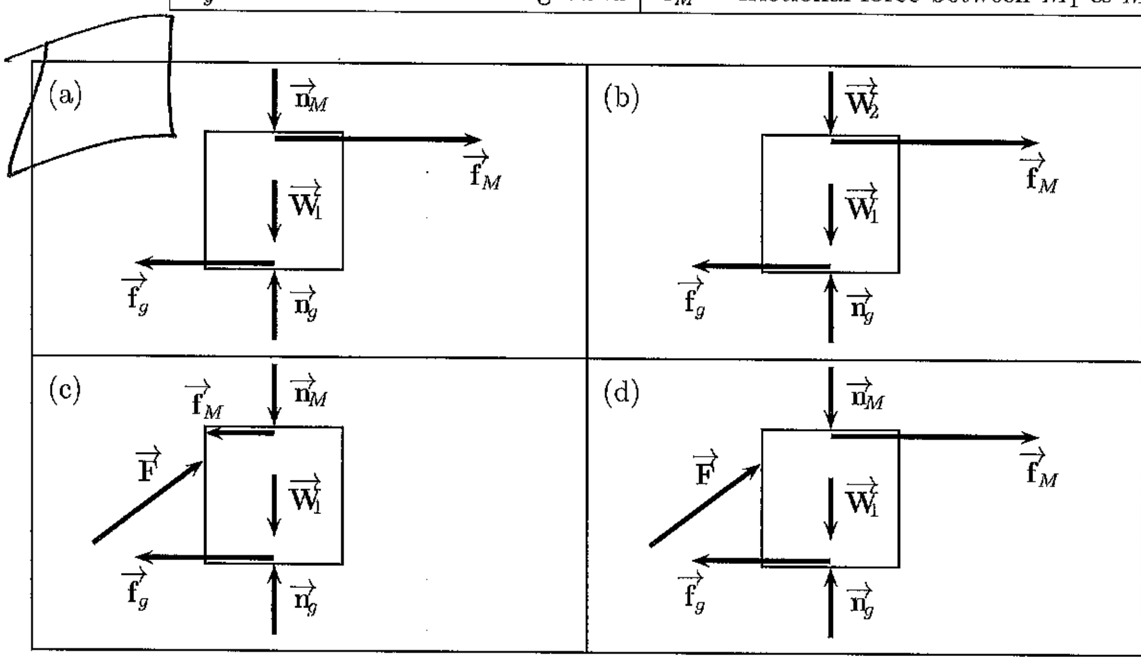
$f_s = 49N - (6.5kg)(9.8m/s^2)\sin 40° = 49N - 40.95N = 8.05N \approx 8.1N$

3. One day finds your physics instructor moving a box, M_1, of old books. On the way to the recycling bin, he finds a box, M_2, of old physics demos, so he places it on top of the first. By exerting a force, $\vec{F}$ at 37° above the horizontal, to the upper box, he gets the combination to slide to the right.

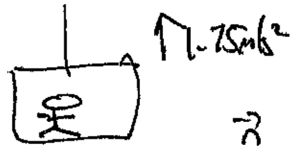


Which of the following is the correct free-body diagram for M_1? Assume the following definitions.

$\vec{W}_1$ = Weight of M_1	$\vec{W}_2$ = Weight of M_2
$\vec{n}_g$ = normal force due to ground	$\vec{n}_M$ = normal force between M_1 & M_2
$\vec{f}_g$ = frictional force due to ground	$\vec{f}_M$ = frictional force between M_1 & M_2



$\vec{F}$ only Applied to M_2, so not on M_1's fbd ⇒ Not (c) or (d). THE Force Between M_1 AND M_2 IS A NORMAL FORCE (AND NOT EQUAL to $\vec{W}_2$!) so (a) IS CORRECT



4. An 80-kg man is riding in an elevator that is accelerating upwards at $1.75\, m/s^2$. What is the *reaction* to his apparent weight?

FORCES ON MAN

(a) The downward 784 N force on the man	
(b) The upward 924 N force on the man	
(c) The upward 784 N force on the earth	
(d) The downward 924 N force on the elevator	✓

$\sum F_y = Ma_y \Rightarrow n - w = Ma_y$

$\Rightarrow n = W + Ma_y = Mg + Ma_y$

$\Rightarrow n = M(g + a_y)$

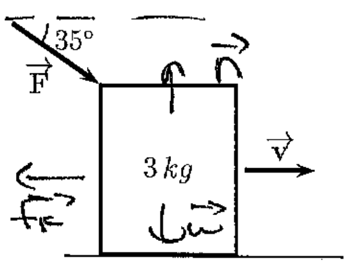
$= 80kg(9.8 m/s^2 + 1.75 m/s^2)$

$= 80kg(11.55 m/s^2) = 924N$

APPARENT WEIGHT

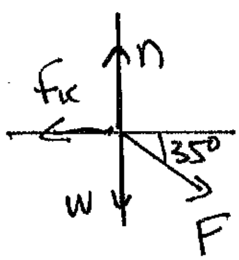
$\vec{n} = 924N$ IS THE FORCE ON THE MAN. THE REACTION IS A DOWNWARD 924N FORCE ON THE ELEVATOR

5. A 3.0 kg crate is being pushed across a horizontal floor by applying a force $\vec{F}$, 35° below the horizontal. If the coefficient of kinetic friction is $\mu_k = 0.25$, what force F is needed to accelerate the crate at $2.0\, m/s^2$?



Forces: $\vec{n}$ up, $\vec{w}$ down, $\vec{f_k}$ to left (opposite to $\vec{v}$), $\vec{F}$

(a) 16.3 N	(b) 7.32 N
(c) 19.8 N ✓	(d) 13.35 N



$\sum F_x = Ma_x, \quad \sum F_y = Ma_y. \quad a_x = a = 2 m/s^2, a_y = 0$

$\sum F_y = 0 \Rightarrow n - W - F\sin 35° = 0 \Rightarrow n = W + F\sin 35°$

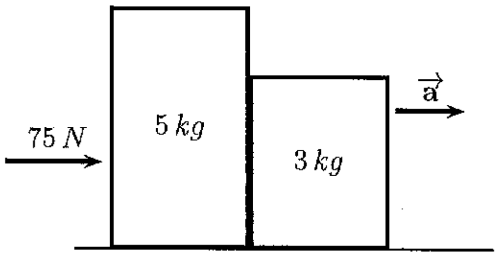
$n = (3kg)(9.8 m/s^2) + F\sin 35° = 29.4N + F\sin 35°$

$f_k = \mu_k n = .25(29.4N + F\sin 35°) = 7.35N + F(.25\sin 35°)$

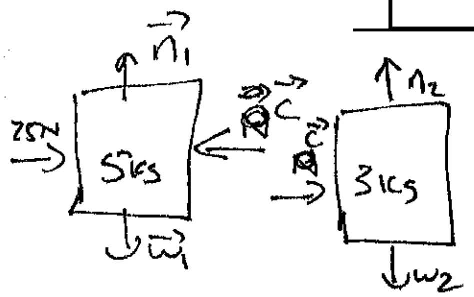
$\sum F_x = Ma_x \Rightarrow F\cos 35° - f_k = Ma \Rightarrow F\cos 35° - [7.35N + F(.25\sin 35°)] = Ma$

$\Rightarrow F(\cos 35° - .25\sin 35°) = 7.35N + (3kg)(2 m/s^2) = 13.35N \Rightarrow F = \frac{13.35N}{.676} = 19.8N$

6. Sitting on a horizontal surface sits two crates, one 5.0 kg, the other 3.0 kg. A 75 N, horizontal force is exerted on the crate to the left making the two masses accelerate. Ignoring friction, how large is the horizontal normal force that the one mass exerts on the other?



(a) 46.875 N	(b) 28.125 N
(c) 75 N	(d) 0 N



EQUAL Acceler.

$\sum F_x = Ma_x \Rightarrow 75N - C = 5kg(a)$

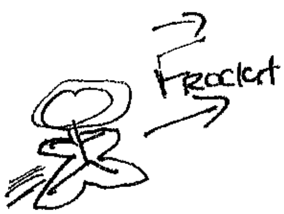
AND $C = 3kg(a)$

$\Rightarrow 75N = (5kg + 3kg)a \Rightarrow a = \frac{75N}{8kg} = 9.375 m/s^2$

$C = 3kg(9.375 m/s^2) = 28.125N$

7. A man who weighs 720 N on earth, surprisingly finds himself in the middle of outer space. Luckily, he is in a spacesuit and, even better, there is a rocket next to him. What force must the rocket exert on the man in order to give him an acceleration of 9.8 m/s^2?

(a) 720 N	(b) 0 N	(c) 1440 N	(d) 360 N

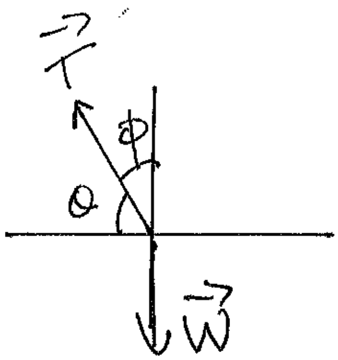


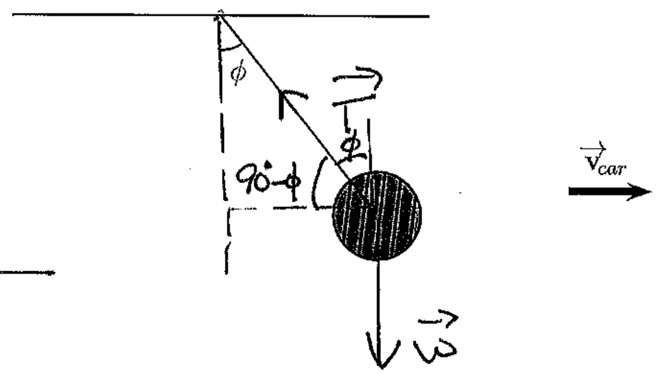
F_{rocket} IS ONLY Force $\Rightarrow \sum F = Ma$

IS $F_{rocket} = Ma$, $a = g = 9.8 m/s^2$

$\Rightarrow F_{rocket} = Mg = W = 720N$

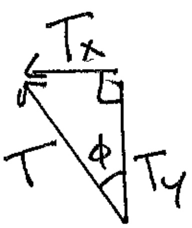
8. One day finds you and your physics instructor going on a drive in his orange-colored, 1973 Gremlin. Hanging from the rear-view mirror, by a massless string, is a 0.65-kg mass pair of pink, fuzzy dice (schematically shown as a sphere in the picture below). At one point during your drive, the dice are hanging at an angle $\phi = 12°$, what is the acceleration of the car at this instant? Also, given the direction of the car's velocity, is the car accelerating or decelerating?





Forces; tension AND weight

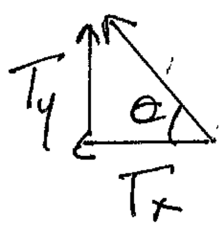
SO EITHER USE NON-STANDARD ϕ



$T_x = -T\sin\phi$ (LEFT IS Negative)

$T_y = T\cos\phi$ (up is positive)

OR USE SEMI-standard $\theta = 90° - \phi$



$T_x = -T\cos\theta$

$T_y = T\sin\theta$

CAR IS EITHER ACCELERATING OR DECELERATING $\Rightarrow \vec{a}$ EITHER parallel OR 180° to $\vec{V}_{car}$

$\Rightarrow \quad a_x = a = ?\ , \quad a_y = 0$

T_x to Left only FORCE IN $x \Rightarrow$ DECELERATING

$$\sum F_y = Ma_y \Rightarrow T\cos\phi - W = 0 \Rightarrow T = \frac{W}{\cos\phi} = \frac{Mg}{\cos\phi}$$

$$\Rightarrow T = \frac{(.65\text{kg})(9.8\text{m/s}^2)}{\cos 12^\circ} = \frac{6.37\text{N}}{\cos 12^\circ} = 6.5123\text{ N}$$

$$\sum F_x = Ma_x \Rightarrow -T\sin\phi = Ma$$

$$\Rightarrow \boxed{a = -\frac{T\sin\phi}{M} = -\frac{6.5123\text{N}\ \sin 12^\circ}{.65\text{kg}} = 2.083\text{ m/s}^2}$$

FOR you MATH-LOVERS: $T = \frac{Mg}{\cos\phi} \Rightarrow a = \frac{-\frac{Mg}{\cos\phi}\sin\phi}{M}$

$$\Rightarrow a = -g\tan\phi$$