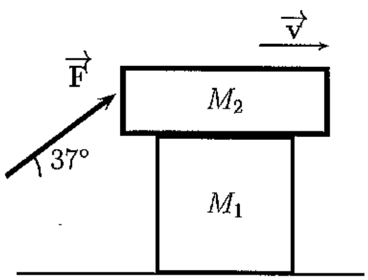
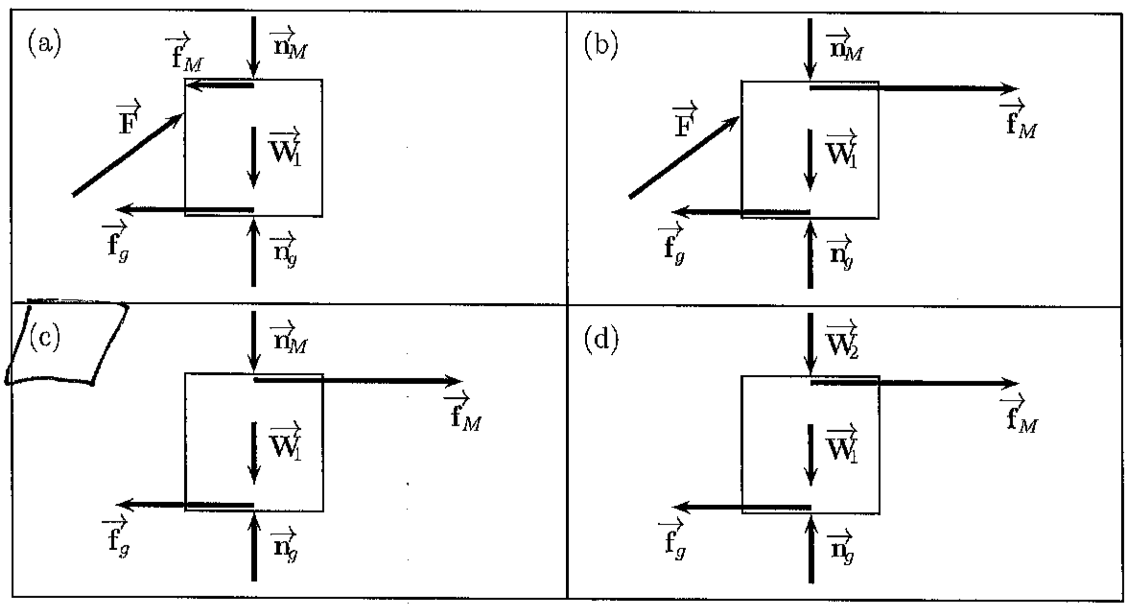
BLUE

1. 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.

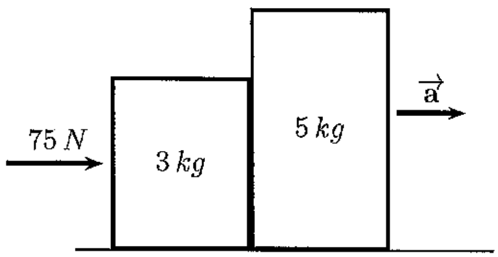
$\vec{W}_1$ = Weight of M_1	$\vec{W}_2$ = Weight of M_2
$\vec{n}_g$ = normal force due to ground	$\vec{n}_M$ = normal force between M_1 & M_2
$\vec{f}_g$ = frictional force due to ground	$\vec{f}_M$ = frictional force between M_1 & M_2



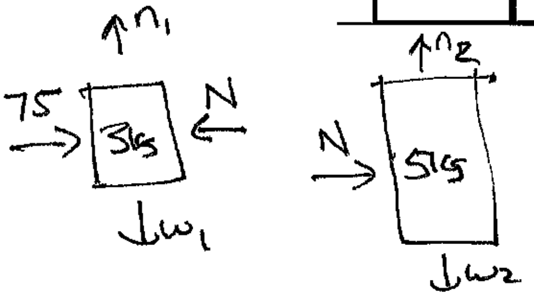
$\vec{F}$ Not Applied to $\vec{M_1}$ so (a), (b) wrong

THE FORCE Between MASSES IS A NORMAL FORCE (AND Not EQUAL to $\vec{W_2}$) SO (c) IS THE Correct Answer

2. Sitting on a horizontal surface sits two crates, one 3.0 kg, the other 5.0 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



$\sum F_x = Ma_x \Rightarrow 75 - N = (3kg)a_1$

$N = (5kg)a_2$

$a_1 = a_2 = a \Rightarrow 75 - N = (3kg)a$

$N = (5kg)a$

$75N = (3kg + 5kg)a$

$\Rightarrow a = \frac{75N}{8kg} = 9.375 m/s^2$

$\Rightarrow N = (5kg)(9.375 m/s^2)$

$= 46.875N$

3. 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) 0 N	(b) 720 N	(c) 1440 N	(d) 360 N

$W = Mg$ $\quad \sum F = Ma$

$a = g \Rightarrow \sum F = Mg$

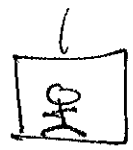
Rocket Force, F_R only

Force $\Rightarrow F_R = Mg$

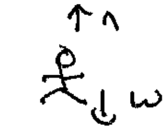
$= 720N$

4. An 80-kg man is riding in an elevator that is accelerating downwards at $2.75\,m/s^2$. What is the *reaction* to his apparent weight?

(a) The downward 784 N force on the man
(b) The upward 564 N force on the man
(c) The upward 784 N force on the earth
(d) The downward 564 N force on the elevator



Forces on Man



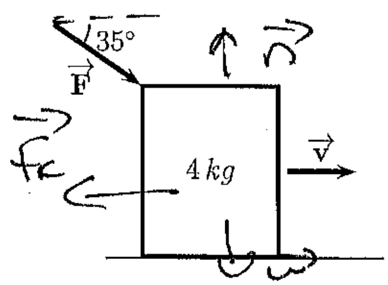
$n - w = ma \Rightarrow$ (Down's Negative)

$n - 80(9.8\,m/s^2) = 80(-2.75)$

$\Rightarrow n = 784N - 220N = 564N$

But $\vec{n} = 564N$ up is Action. The reaction is a 564N force down on elevator.

5. A $4.0\,kg$ crate is being pushed across a horizontal floor by applying a force $\vec{\mathbf{F}}$, 35^o below the horizontal. If the coefficient of kinetic friction is $\mu_k = 0.25$, what force F is needed to accelerate the crate at $2.5\,m/s^2$?



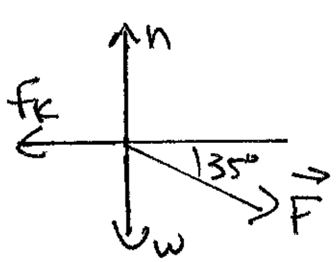
(a) 10 N	(b) 19.8 N
(c) 29.3 N	(d) 24.1 N

Forces $\vec{n}$ up, $\vec{w}$ Down, $\vec{f_k}$ opposite to $\vec{v} \Rightarrow$ left

$\vec{F}$ at $35°$

$\Sigma F_x = ma_x, \quad \Sigma F_y = ma_y$

$a_x = 2.5\,m/s^2, \quad a_y = 0$



$\Sigma F_y = 0 \Rightarrow n - F\sin 35° - w = 0$

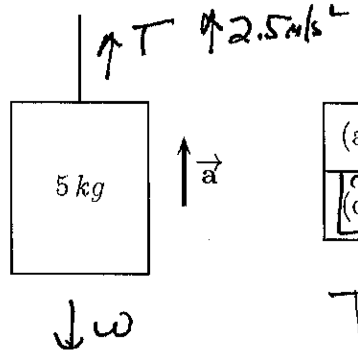
$\Rightarrow n = w + F\sin 35° = (4kg)(9.8\,m/s^2) + F\sin 35° = 39.2N + F\sin 35°$

$f_k = \mu_k n = .25(39.2N + F\sin 35°) = 9.8N + F(.25\sin 35°)$

$\Sigma F_x = ma_x \Rightarrow F\cos 35° - f_k = ma_x \Rightarrow F\cos 35° - (9.8N + F .25\sin 35°) = ma$

$\Rightarrow F(\cos 35° - .25\sin 35°) = (4kg)(2.5\,m/s^2) + 9.8N \Rightarrow F = \frac{19.8N}{.6758} = 29.3N$

6. A 5.0 kg mass is attached to a massless string which is accelerated upwards 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

$\sum F_y = Ma_y$

$T - W = Ma_y$

$\Rightarrow T = W + Ma_y$

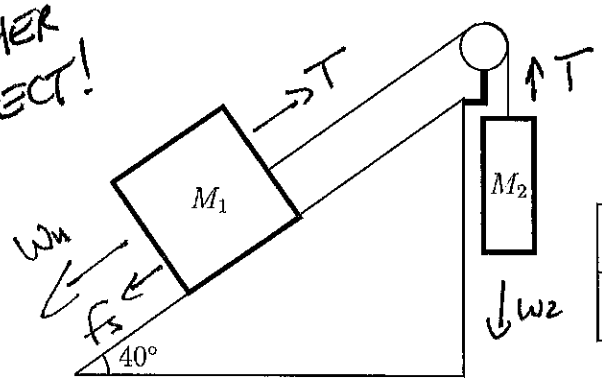
$T = (5kg)(9.8m/s^2) + (5kg)(2.5m/s^2)$

$= 61.5N$

*Sigh! On closer examination $\mu_s n = .8 M_1 g \cos 40° = 21N$ which obviously < 27N so masses would move. So either answer is correct!

7. A $M_1 = 3.5\,kg$ 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 $\mu_s = 0.8$. 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 $\mu_s n$*



(a) 22.0 N	(b) 21.0 N
(c) 49 N	(d) 27.0 N

$(5kg)(9.8m/s^2)$

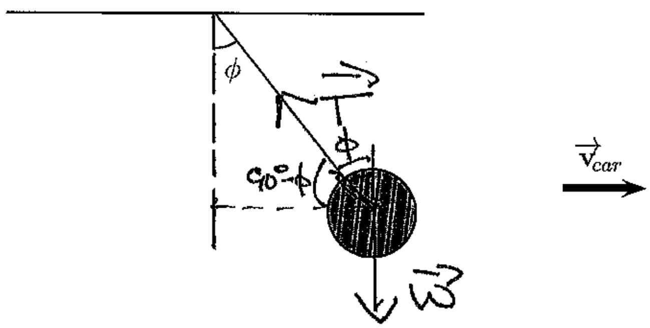
For M_2: $\sum F_y = M_2 a_{2,y}$. $a_{2,y} = 0 \Rightarrow T - W_2 = 0 \Rightarrow T = W_2 = 49N$

So for M_1: $\sum F_{\parallel} = M_1 a_{\parallel} \Rightarrow T - W_{\parallel} - f_s = 0$ since $a_{\parallel} = 0$ too

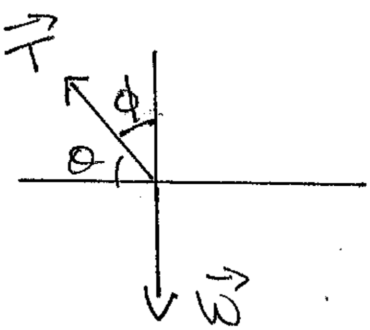
$\Rightarrow f_s = T - W_{\parallel} = 49N - (3.5kg)(9.8m/s^2)\sin 40° = 49N - 22N$

$= 27N$

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 $\phi = 22°$, 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 ON DICE : TENSION AND WEIGHT

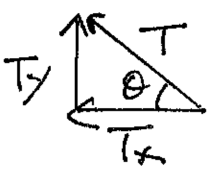


SO EITHER USE NON-STANDARD ϕ

$T_x = T\sin\phi$, $T_y = T\cos\phi$

↑ left is negative

OR SEMI-STANDARD $\theta = 90° - \phi$



$T_x = -T\cos\theta$

$T_y = T\sin\theta$

$\sum F_x = Ma_x$, $\sum F_y = Ma_y$

CAR IS EITHER ACCELERATING OR DECELERATING

$\Rightarrow \vec{a}$ parallel OR 180° to $\vec{V}_{car}$

T_x to LEFT $\Rightarrow$ DECELERATING AND $a_y = 0$

$$\sum F_y = Ma_y \Rightarrow T_y - W = 0$$

$$\Rightarrow T\cos\phi = W \Rightarrow T = \frac{W}{\cos\phi} = \frac{(.65\text{kg})(9.8\text{m/s}^2)}{\cos 22^\circ}$$

$$\Rightarrow T = 6.87\text{N}$$

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

$$\therefore -6.87\text{N}\sin 22^\circ = (.65\text{kg})a$$

$$\Rightarrow a = -\frac{6.87\text{N}\sin 22^\circ}{.65\text{kg}} = -3.96\text{m/s}^2$$

OR FOR MATH LOVERS: $T = \frac{Mg}{\cos\phi}$ so $-T\sin\phi = Ma$

$$\Rightarrow -\frac{Mg\sin\phi}{\cos\phi} = Ma \Rightarrow a = -g\tan\phi$$