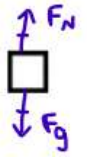
Name Key Hour _____

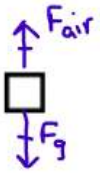
Free Body Diagrams:

Construct free-body diagrams for the following physical situations. Label all forces (e.g, F_{grav}, F_{norm}, F_{app}, F_{frict}, F_{air}, F_{tens}, etc.).

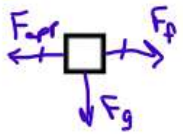
a. A physics book rests upon a level table.



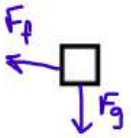
b. A skydiver is falling and has reached a terminal velocity.



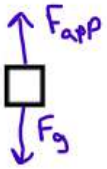
c. A large crate is being pushed leftward at a constant velocity.



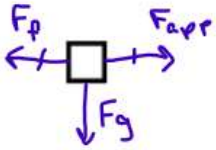
d. A sledder has reached the bottom of a hill and is coasting rightward while slowing down.



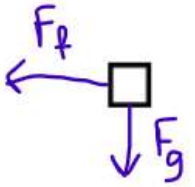
e. A ball is moving upwards towards its peak. Ignore air resistance.



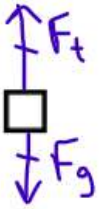
f. An air track glider moves rightward at constant speed.



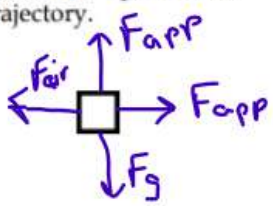
g. The brakes are applied to a rightward moving car and it skids to a stop.



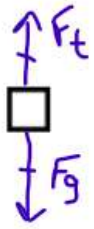
h. A spider is slowly descending a thin silk thread at constant speed.



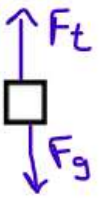
i. A projectile is moving upwards and rightwards towards the peak of its trajectory.



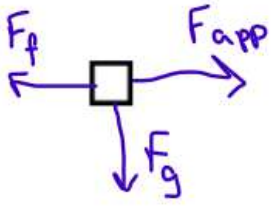
j. An elevator is rising at a constant velocity; it is not touching the elevator shaft.



k. An upward rising elevator is slowing down; it is not touching the elevator shaft.

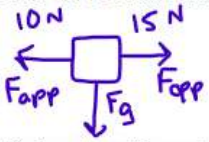


l. A force is applied to accelerate a crate across a rough horizontal surface.



Net Force

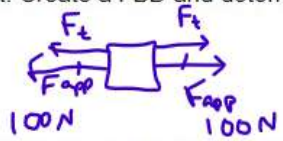
1. A box is being pushed by two stellar science students, one on each side of the box. Dalton is pushing the box with a force of 10 N to the left. DeAndre is pushing the box with a force of 15 N to the right. Create a FBD and determine the net force.



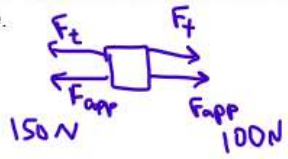
Net force = 15 N − 10 N
= 5 N right

2. During tug of war Janelle felt like she was supergirl and attempted to beat Rameek. Janelle, with one arm on the rope, applied a 100 N force to the left, while Rameek applied a 100 N force with both hands to the right. Create a FBD and determine the net force.

Net force = 0 N

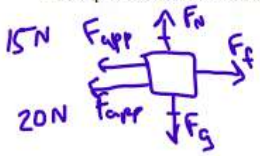


3. Janelle finally decided to take this seriously and put both hands on the rope and applied a 150 N force to the left, while Rameek still struggled with his 100 N force to the right. Create a FBD and determine the net force.



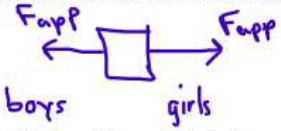
Net force = 150 − 100
= 50 N left

4. Sarah and Kyon were attempting to push Joaquin on the scooter with enough force so Joaquin would run into their teacher. They figured out they needed a 50 N force to run the scooter into Mr. Whitmore. Sarah and Kyon were both applying force toward Mr. Whitmore. Sarah was applying a 20 N force to the left, and Kyon was applying a force of 15 N to the left. Create a FBD and determine the net force. Did the Joaquin scooter rocket hit the teacher? How can they get it to hit him?



Net force = 15 + 20 = 35 N

5. In a third hour battle the girls were able to overcome the boys 3 times in the tug of war. The boys had 8 individuals each pulling with a force of 30 N. The 10 girls were able to pull the rope toward them with a net force of 50 N. Create a FBD and determine the net force. Who won?

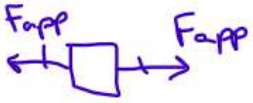


boys = 8 × 30 = 240 N

Net force = 50 N girls

50 N = girls − boys
50 = g − 240
50 + 240 = g
290 N = girls

6. During 4th period Jada was a beast. She resisted the forces applied by 5 people in his class all at once. Each person applied a force of 17 N and Jada still did not move. Create a FBD and determine the net force. How much force was Jada pushing back with for her to stay still? How many people would it take to push Jada if she can withstand a force of 250 N?



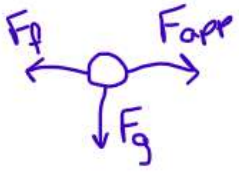
5 × 17 = 85 N to stand still

250 ÷ 17 = 14.7 → 15 people

1D Acceleration with Forces Problems

Directions: For each problem below, DRAW A FREEBODY DIAGRAM. Then write a net force equation, determine if your object is in equilibrium, then solve.

1. A car speeds up from rest to a velocity of 25 m/s over a time interval of 10 seconds. If the car is 3000 kg, what was the net force exerted on the car?

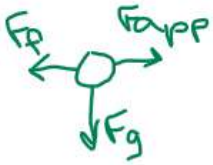


$V_i = 0$
$V_f = 25\ m/s$
$t = 10\ s$
$m = 3000\ kg$
$F = ?$
$a = ?$

$V_f = V_i + at$
$V_f - V_i = at$
$\frac{V_f - V_i}{t} = a$
$\frac{25-0}{10} = a = 2.5\ m/s^2$

$F = ma$
$F = (3000)(2.5)$
$F = 7500\ N$

2. Josh, with a mass of 60 kg, is running on a track. Towards the end of the race, he decides to sprint to the end. If he accelerates from 8 m/s to 10 m/s over a time interval of 30 seconds, how much force did he exert?

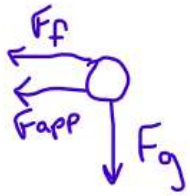


$m = 60\ kg$
$V_i = 8\ m/s$
$V_f = 10\ m/s$
$t = 30\ s$
$F = ?$
$a = ?$

$V_f = V_i + at$
$a = \frac{V_f - V_i}{t}$
$a = \frac{10-8}{30}$
$a = 0.07\ m/s^2$

$F = ma$
$F = (60)(0.07)$
$F = 4.2\ N$

3. Brandon decelerates his car from a speed of 20 m/s to rest when he gets pulled over by the cop, Jon. If his car has a mass of 4500 kg and he stops in 15 seconds, how much force was exerted on the car?



$V_i = 20\ m/s$
$V_f = 0$
$m = 4500\ kg$
$t = 15\ s$
$F = ?$
$a = ?$

$a = \frac{V_f - V_i}{t}$
$a = \frac{0-25}{15}$
$a = -1.7\ m/s^2$

$F = ma$
$F = (4500)(-1.7)$
$F = -7650\ N$

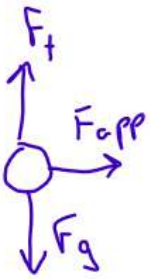
4. James pushes on a shopping cart originally at rest with a force of 32 Newtons. If the cart has a mass of 19 kg and he pushes for 30 seconds, how fast is the cart going after 30 seconds?

$F = 32\ N$
$m = 19\ kg$
$t = 30s$
$V_i = 0$
$V_f = ?$
$a = ?$

$F = ma$
$\frac{F}{m} = a$
$\frac{32}{19} = a$
$1.7\ m/s^2 = a$

$V_f = V_i + at$
$V_f = 0 + (1.7)(30)$
$V_f = 51\ m/s$

5. Rachel can punch with a force of 27 Newtons. If she punches a punching bag that weighs 100 kg and she is in contact with the punching bag for 0.94 seconds, how fast is the bag moving?



$F = 27\ N$
$m = 100\ kg$
$t = 0.94s$
$V_i = 0$
$V_f = ?$
$a = ?$

$F = ma$
$\frac{F}{m} = a$
$\frac{27}{100} = a$
$0.27\ m/s^2 = a$

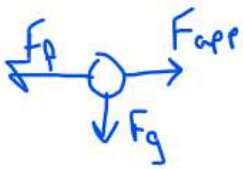
$V_f = V_i + at$
$V_f = 0 + (0.27)(0.94)$
$V_f = 0.25\ m/s$

6. Simone is pushing Sam on a sled. The sled has a mass of 23 kg and Sam has a mass of 64 kg and are originally at rest. Simone pushes with a force of 19 Newtons and speeds up the sled and Sam to a speed of 10.4 m/s. How long was Simone pushing the sled and Sam?

$m = 23\ kg + 64\ kg = 87\ kg$
$V_i = 0$
$F = 19\ N$
$V_f = 10.4\ m/s$
$t = ?$
$a = ?$

$F = ma$
$a = \frac{F}{m} = \frac{19}{87}$
$a = 0.22\ m/s^2$

$V_f = V_i + at$
$-V_i \quad -V_i$
$\frac{V_f - V_i}{a} = \frac{at}{a}$
$t = \frac{V_f - V_i}{a} = \frac{10.4 - 0}{0.22}$
$t = 47s$



7. A package of instruments is attached to a helium-filled weather balloon that exerts an upward force of 45 N.

A. If the instrument package weighs 10.0 kg, will the balloon be able to lift it?

$F = 45\ N$

$m = 10\ kg$

$a = -9.8\ m/s^2$

$F_g = ma = (10)(-9.8)$

$F_g = -98\ N$

the balloon will not be able to lift it

B. What is the upward acceleration if the instruments weigh 2.0 kg?

$F = 45\ N$

$m = 2\ kg$

$a = ?$

$F = ma$

$a = \frac{F}{m} = \frac{45}{2}$

$a = 22.5\ m/s^2$

8. A 9.7-kg box experiences a net force of 41 N while it is being lifted. What is the acceleration of the box?

$m = 9.7\ kg$

$F = 41\ N$

$a = ?$

$a = \frac{F}{m} = \frac{41}{9.7}$

$a = 4.2\ m/s^2$

9. In a lab experiment, you attach a 2.0-kg weight to a spring scale. You lift the scale and weight such that the net force acting upwards is 22.5 Newtons.

A. What is the value and direction of the acceleration on the weight?

$m = 2.0\ kg$

$F_{net} = 22.5\ N \uparrow$

$a = ?$

$F = ma$

$a = \frac{F}{m} = \frac{22.5}{2.0}$

$a = 11.25\ m/s^2$ up

B. How far do you lift the weight in the first 2.0-s interval?

$t = 2.0\ s$

$V_i = 0$

$d = ?$

$d = V_i t + \frac{1}{2} a t^2$

$d = (0 \cdot 2) + \frac{1}{2}(11.25)(2^2)$

$d = 0 + \frac{1}{2}$

Forces with Friction

1. Matt is trying to push a 10 kg box. The coefficient of static friction between a 10 kg object and the floor is 0.50. What is the maximum force that can be applied on the object before it starts moving?

$m = 10\ kg$ $\quad N = ma = 10 \cdot 9.8 = 98\ N$

$\mu = 0.50$ $\quad F_f = \mu N = (0.50)(98)$

$F_f = 49\ N$

2. If the coefficient of kinetic friction between a crate and the floor is 0.20, how much force is needed to slide a 92 kg crate at a constant velocity across the floor?

$\mu = 0.20$ $\quad F_f = \mu N = (0.20)(92)(9.8)$

$F_f = ?$ $\quad F_f = 180\ N$

$m = 92\ kg$

$a = 9.8\ m/s^2$

3. A 25 kg block is initially at rest on a rough, horizontal surface. A horizontal force of 75 N is required to set the block in motion, and a 60 N force is required to keep it in motion at a constant speed once it is moving.

a. What is the coefficient of static friction?

$75\ N = \mu_s (25 \cdot 9.8)$ $\quad \mu_s = 0.31$

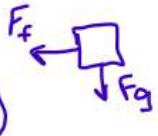
$75 = \mu_s (245)$

b. What is the coefficient of kinetic friction?

$60 = \mu_k (245)$ $\quad \mu_k = 0.24$

4. Cameron hits a hockey puck with a mass of 0.5 kg. The coefficient of kinetic friction between the hockey puck and the ice is 0.11. $\mu = 0.11$ $\quad m = 0.5\ kg$

a. What is the deceleration of the puck as it comes to a stop? (Hint: there is no applied force)



$F_f = \mu N = (0.11)(0.5)(9.8)$ $\quad F = ma$

$F_f = 0.54\ N$ $\quad 0.54 = (0.5)a$ $\quad a = -1.1\ m/s^2$

b. How far does the hockey puck travel before it comes to a stop if he gives it an initial velocity of 30 m/s? $a = -1.1\ m/s^2$

$V_i = 30\ m/s$ $\quad V_f^2 = V_i^2 + 2ad$

$V_f = 0$ $\quad d = ?$ $\quad 0 = 30^2 + 2(-1.1)d$

$\frac{-900}{-2.2} = \frac{-2.2d}{-2.2}$ $\quad 409\ m = d$