

Name: _____

KEY

ACP Physics - Dynamics Problem Set

1) A rocket blasts off vertically from rest and attains a speed of 45 m/s in 15.0 s. An astronaut on board has a mass of 57 kg.

(a) What is the net force acting on the astronaut?

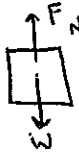
$a = \text{FOUND BY KINEMATICS}$

$v = v_0 + at$

$a = 3 \text{ m/s}^2 \text{ UP}$

$\Sigma F = ma$
 $= (57 \text{ kg})(3 \text{ m/s}^2 \text{ UP})$
 $= 171 \text{ N UP}$

(b) What is the astronaut's apparent weight (i.e. normal force acting on him)?



$W = mg = 559 \text{ N}$

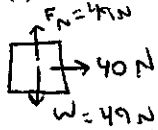
$\Sigma F = 171 \text{ N UP}$ (UP FORCE WINNING BY 171 N)

$F_N = W + 171 \text{ N}$

$= 730 \text{ N}$

2) A horizontal force of 40.0 N accelerates a 5.0-kg block resting on the floor.

(a) If the floor is frictionless, what is the acceleration of the block?

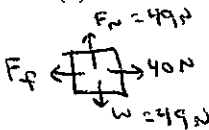


$\Sigma F = 40 \text{ N}$

$\Sigma F = ma$

$8 \text{ m/s}^2 = a$

(b) The actual acceleration of the block is measured to be 6.0 m/s². What is the magnitude of the frictional force?



$\Sigma F = ma$
 $= (5.0 \text{ kg})(6.0 \text{ m/s}^2)$
 $= 30 \text{ N}$ (YOU ARE WINNING BY 30 N)

$F_f \text{ MUST BE } 10 \text{ N}$

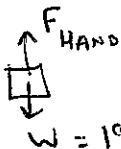
(c) What is the coefficient of kinetic friction between the block and the floor?

$F_f = \mu_k F_N$

$\frac{F_f}{F_N} = \mu_k$

$\mu_k = 0.204$

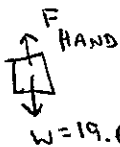
3) A man lifts a 2.0-kg stone vertically with his hand at a constant upward velocity of 1.5 m/s. What is the magnitude of the force of the man's hand on the stone?



EQUILIBRIUM ($\Sigma F = 0$)

$F_{\text{HAND}} = W = 19.6 \text{ N}$

4) A man lifts a 2.0-kg stone vertically with his hand at a constant upward acceleration of 1.5 m/s². What is the magnitude of the force of the man's hand on the stone?



$\Sigma F = ma$
 $= 3 \text{ N UP}$ ("UP" WINNING BY 3 N)

$F_{\text{HAND}} = W + 3 \text{ N} = 22.6 \text{ N}$

5) A 10-N box rests on a surface. The coefficients of static and kinetic friction are 0.8 and 0.5, respectively.

(a) How much force is required to start moving the box? ← MUST OVERCOME STATIC FRICTION



$F_f \leq \mu_s F_N$
 $F_f \leq (0.8)(10 \text{ N})$
 $F_f \leq 8 \text{ N}$

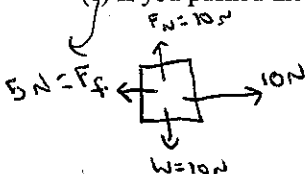
MUST PUSH WITH AT LEAST 8 N

(b) Once the box is in motion, how much force is required to move the box at a constant rate? ← MUST BALANCE KINETIC FRICTION

$F_f = \mu_k F_N$
 $= (0.5)(10 \text{ N})$
 $= 5 \text{ N}$

MUST PUSH WITH 5 N TO BE IN EQUILIBRIUM

(c) If you pushed the box with a force twice as strong as what you found in Part (b), what is the acceleration of the box?



$\Sigma F = 5 \text{ N}$ (YOU'RE WINNING BY 5 N)

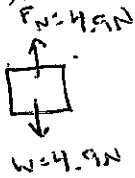
$a = \frac{\Sigma F}{m} = \frac{5 \text{ N}}{1.02 \text{ kg}}$

$= 4.90 \text{ m/s}^2$

IF THE BOX WEIGHS 10 N,
 ITS MASS IS:

$m = \frac{W}{g} = 1.02 \text{ kg}$

- 6) A 0.5-kg brick sits at on a wooden horizontal floor ($\mu_s = 0.58, \mu_k = 0.34$).
 (a) How much horizontal force must be exerted on the brick to start moving it? (OVERCOME STATIC FRICTION)



$$F_f \leq \mu_s F_N$$

$$F_f \leq 2.84 \text{ N}$$

MUST PUSH WITH AT LEAST 2.84 N

- (b) How much horizontal force must be exerted on the brick to keep it moving at a constant velocity once it is in motion?

$$F_f = \mu_k F_N$$

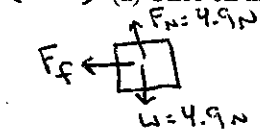
$$= 1.67 \text{ N}$$

$\Sigma F = 0$
MUST BALANCE F_f KINETIC

MUST PUSH WITH EXACTLY 1.67 N

- 7) A 0.5-kg brick is sliding along a horizontal frictionless surface at a constant velocity of +8.0 m/s. It then slides onto a wooden horizontal floor ($\mu_s = 0.58, \mu_k = 0.34$).

- (a) Once on the wooden floor, is the brick affected by static friction or kinetic friction?



- (b) What is the net horizontal force acting on the brick, assumed to be solely due to friction?

$$F_f = \mu_k F_N$$

$$= (0.34)(4.9 \text{ N})$$

$$= 1.67 \text{ N} = \Sigma F$$

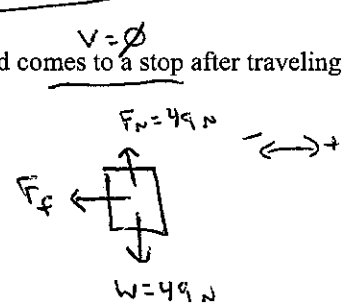
- (c) What is the magnitude and direction of the brick's acceleration?

$$a = \frac{\Sigma F}{m} = 3.34 \text{ m/s}^2 \text{ IN THE NEGATIVE DIRECTION (OPPOSITE MOTION)}$$

- 8) A 5.0-kg block, initially traveling at +5.5 m/s, slows due solely to friction and comes to a stop after traveling +2.8 m.
 (a) Determine the acceleration of the block.

$$v^2 = v_0^2 + 2ad$$

$$a = -5.40 \text{ m/s}^2$$



- (b) What is the magnitude of the frictional force (i.e. the net force)?

$$\Sigma F = ma$$

$$= (5.0 \text{ kg})(-5.40 \text{ m/s}^2)$$

$$= -27.0 \text{ N}$$

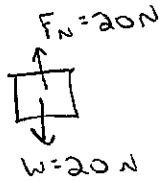
$$F_f = 27.0 \text{ N}$$

- (c) What is the coefficient of kinetic friction between the block and the floor?

$$\mu_k = \frac{F_f}{F_N} = \frac{27.0 \text{ N}}{49 \text{ N}} = 0.551$$

9) A 20-N box of books sits at rest on a floor. The coefficients of static and kinetic friction are 0.50 and 0.38, respectively.

(a) How much force do you need to exert horizontally to start moving the box? (OVERCOME STATIC FRICTION)

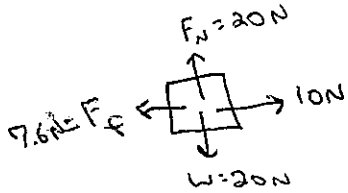


$$F_f \leq \mu_s F_N$$

$$\leq 10\text{ N}$$

MUST PUSH WITH AT LEAST 10N

(b) The force found in part (a) is exerted on the box once it is in motion. Determine the box's acceleration.



KINETIC FRICTION!

$$F_f = \mu_k F_N$$

$$= 7.6\text{ N}$$

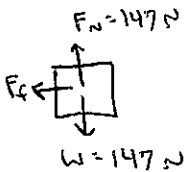
$$\Sigma F = 2.4\text{ N (YOU'RE WINNING BY 2.4N)}$$

$$a = \frac{\Sigma F}{m} = 1.18\text{ m/s}^2$$

$$m = \frac{W}{g} = \frac{20\text{ N}}{9.8\text{ m/s}^2} = 2.04\text{ kg}$$

7) A 15-kg wooden box, initially moving at +8 m/s, is sliding across a wooden surface ($\mu_k = 0.30$).

(a) What is the net force acting on the box (assumed to be solely due to friction)?



$$F_f = \mu_k F_N$$

$$= 44.1\text{ N IN THE NEGATIVE DIRECTION OPPOSING MOTION}$$

(b) What is the acceleration of the box?

$$a = \frac{\Sigma F}{m} = \frac{-44.1\text{ N}}{15\text{ kg}} = -2.94\text{ m/s}^2$$

(c) How much time does it take the box to come to rest?

$$v_0 = +8\text{ m/s}$$

$$v = 0$$

$$a = -2.94\text{ m/s}^2$$

$$t = ?$$

$$v = v_0 + at$$

$$2.72\text{ s} = t$$

(d) How far did the box slide before coming to rest?

$$d = ? \quad v^2 = v_0^2 + 2ad$$

$$+10.9\text{ m} = d$$

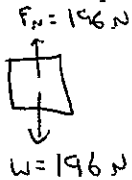
$$d = v_0 t + \frac{1}{2} a t^2$$

$$d = +10.9\text{ m}$$

$$d = \frac{1}{2} (v + v_0) t$$

$$d = +10.9\text{ m}$$

10) A dockworker loading crates on a ship finds that a 20-kg crate, initially at rest, requires a 75-N horizontal force to set it into motion. However, after it is in motion, a horizontal force of only 60 N is required to keep the crate moving with a constant speed. Find the coefficients of static and kinetic friction between the crate and the floor.



$$F_f \leq \mu_s F_N$$

$$F_{f_{\text{max}}} = \mu_s F_N$$

$$\mu_s = \frac{F_{f_{\text{max}}}}{F_N}$$

$$\mu_s = 0.383$$

MUST BE KINETIC FRICTION FORCE

MUST BE MAX. STATIC FRICTION FORCE

$$F_f = \mu_k F_N$$

$$\mu_k = \frac{F_f}{F_N}$$

$$\mu_k = 0.306$$

11) A 10-kg box of books rests on a horizontal surface.

(a) If the coefficient of static friction between the box and the floor is 0.4, how much force is required to move the box?

(OVERCOME STATIC FRICTION)

$$F_N = 98 \text{ N}$$

$$F_f \leq \mu_s F_N$$

$$F_f \leq 39.2 \text{ N}$$

MUST PUSH WITH AT LEAST 39.2 N

$$W = 98 \text{ N}$$

(b) The coefficient of kinetic friction is 0.32. If the same force found in part (a) is applied to the box once it is in motion, find the acceleration of the box.

$$F_N = 98 \text{ N}$$

$$F_f = \mu_k F_N = 31.4 \text{ N}$$

KINETIC FRICTION

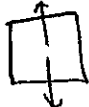
$$\Sigma F = 7.8 \text{ N (YOU'RE WINNING)}$$

$$a = \Sigma F / m = 0.78 \text{ m/s}^2$$

12) A 6.00-kg box is sliding across the horizontal floor of an elevator. The coefficient of kinetic friction between the box and the floor is 0.360. Determine the kinetic frictional force that acts on the box when the elevator is:

(a) stationary. $\Sigma F = 0$

$$F_N = 58.8 \text{ N}$$



$$W = 58.8 \text{ N}$$

$$F_f = \mu_k F_N = (0.360)(58.8 \text{ N}) = 21.2 \text{ N}$$

(b) accelerating upward at 1.20 m/s^2 .

UP WINNING! $F_N > W$

$$F_N = 66.0 \text{ N}$$



$$W = 58.8 \text{ N}$$

$$\Sigma F = ma = (6.00 \text{ kg})(1.20 \text{ m/s}^2 \text{ up}) = 7.2 \text{ N up}$$

(F_N IS 7.2 N GREATER THAN W)

$$F_f = \mu_k F_N = (0.360)(66.0 \text{ N}) = 23.8 \text{ N}$$

(c) accelerating downward at 1.20 m/s^2 .

DOWN WINNING! $F_N < W$



$$W = 58.8 \text{ N}$$

$$\Sigma F = ma = (6.00 \text{ kg})(1.20 \text{ m/s}^2 \text{ down}) = 7.2 \text{ N down}$$

(F_N IS 7.2 N LESS THAN W)

$$F_N = 51.6 \text{ N}$$

$$F_f = \mu_k F_N = (0.360)(51.6 \text{ N}) = 18.6 \text{ N}$$