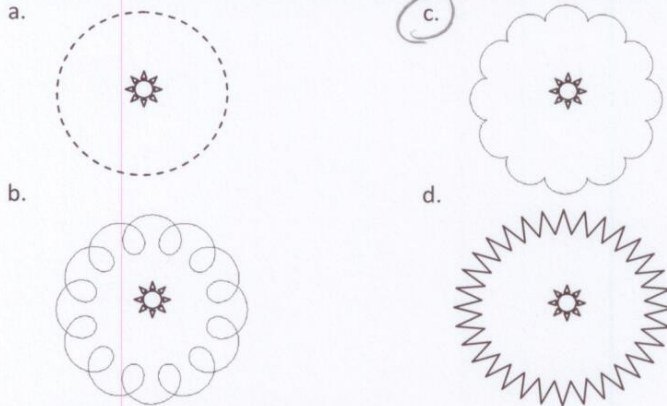


**Exam 2**  
**Physics 220**  
**Spring 2014**

Name: Solution Group: \_\_\_\_\_

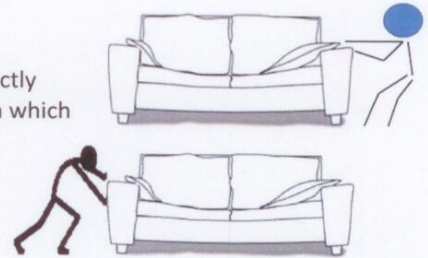
1. Which of the following best depicts the path of the moon around the sun?



e. The moon does not orbit the sun.

2. A person is moving their couch in their living room. In one case, they pull perfectly horizontally. In the other they push at an angle as shown in the 2<sup>nd</sup> diagram. In which case is it easier to move the sofa? When

- a. ☒ Pulling Horizontally  
b. ☐ Pushing at an angle  
c. ☐ Both are equally as difficult



3. A car breaks down out on the road and receives a push back into town by a good Samaritan as shown in the figure to the right. While the man, still pushing the car, is getting started and speeding up to a slow constant speed,

- a. The amount of force with which the man pushes on the car is greater than the force with which the car pushes back on the man.  
b. ☒ The amount of force with which the man pushes on the car is equal to the force with which the car pushes back on the man.  
c. The amount of force with which the man pushes on the car is less than the force with which the car pushes back on the man.  
d. The car does not apply a force on the man.



4. The answer to the above question

- a. depends on whether the man is speeding up, slowing down or moving at a constant speed.  
b. ☒ is always equal and opposite because these are force pairs.  
c. depends on the net force acting on the car  
d. Both a and b  
e. Both a and c

5. A boy is being lifted out of a well by a rope. While he is rising at a constant speed,
- The upward force by the rope is greater than the downward force of gravity
  - ☒ The upward force by the rope is equal to the downward force of gravity
  - The upward force by the rope is less than the downward force of gravity

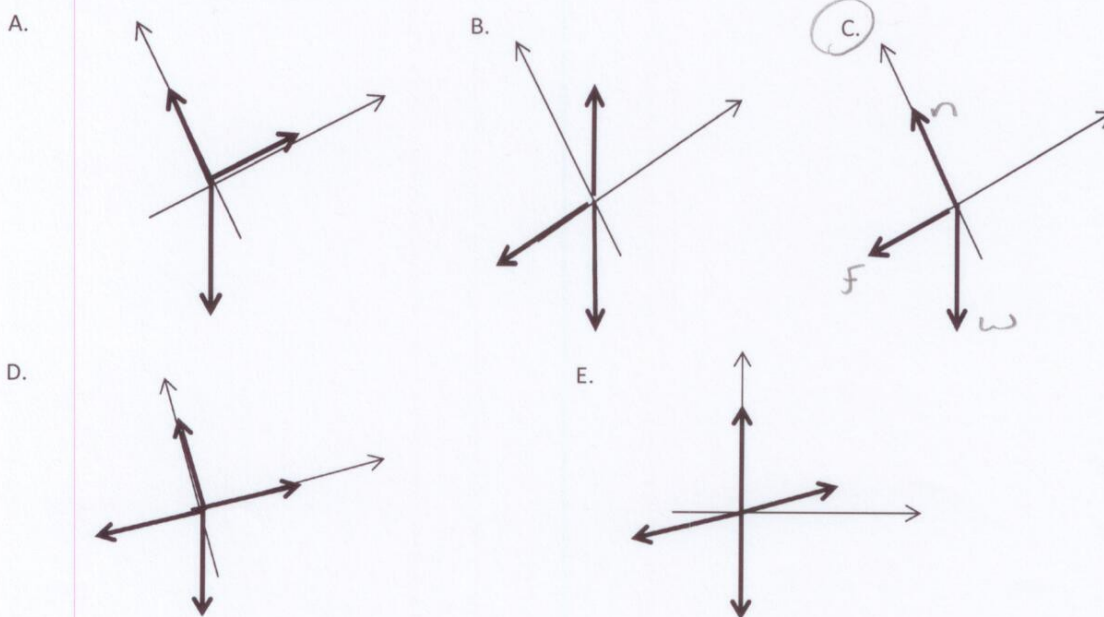
$F_{\text{net}} = 0$   $\vec{F} \uparrow$   $\vec{w} \downarrow$   $\vec{a} = 0$

6. Consider a basketball player jumping up off the gym floor.
- ☒ While jumping the normal force is greater than the players' weight
  - While jumping the normal force is equal to the players' weight
  - While jumping the normal force is less than the players' weight

$\vec{F} \uparrow$   $\vec{w} \downarrow$   $\vec{a} \uparrow$

7. A semi's brakes fail as it heads down I-70. Luckily there's a runaway truck ramp near. The semi goes up the ramp and the deep gravel quickly brings the truck to a stop.

Which free body diagram fits this description?

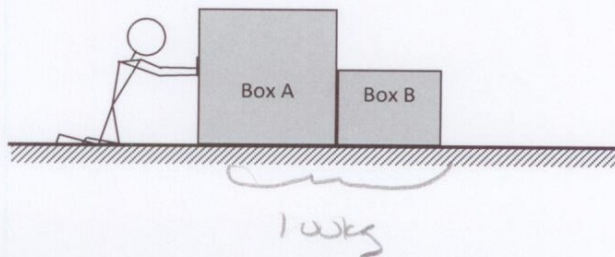


8. The force pair for the semi's normal force is
- The weight of the semi *weight*
  - The gravel on the truck's wheels (pushing against motion) *friction*
  - The ground on the semi *normal*
  - ☒ The semi on the ground
  - The truck's wheels on the gravel (pushing gravel forward)

9. Two boxes are being pushed on a frictionless surface, one in front of the other, as shown in the diagram. Box A has a mass of 70 kg and Box B a mass of 30 kg. The push on Box A is a horizontal force of 200 N. What is the force on Box B?

- 200 N
- 100 N
- 80 N
- ☒ 60 N

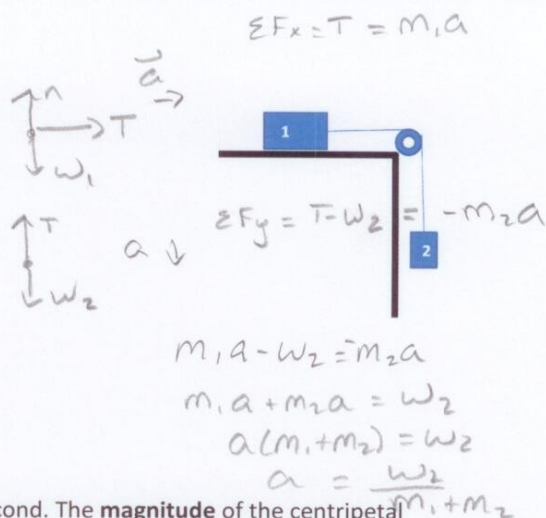
$200\text{ N} = 100\text{ kg } a$   
 $a = 2\text{ m/s}^2$   
 $F_B = 30\text{ kg } 2\text{ m/s}^2$   
 $= 60\text{ N}$





10. What is the acceleration of mass 1 if there is no friction on Mass 1?

- a. More than  $9.8 \text{ m/s}^2$
- b.  $9.8 \text{ m/s}^2$
- ☒ c. Less than  $9.8 \text{ m/s}^2$  but greater than  $0 \text{ m/s}^2$
- d.  $0 \text{ m/s}^2$



11. The moon's gravitational force on the earth is

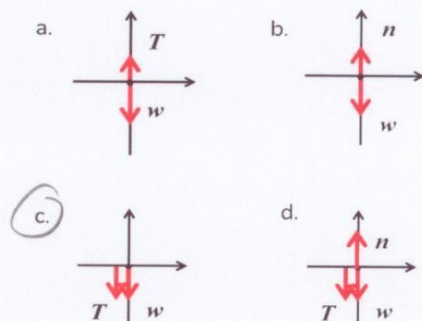
- a. greater than the earth's gravitational force on the moon.
- ☒ b. equal to the earth's gravitational force on the moon.
- c. less than the earth's gravitational force on the moon.

12. A ball on the end of a string swings in a horizontal circle once every second. The **magnitude** of the centripetal acceleration is

- a. Zero
- ☒ b. Constant (but non-zero)
- c. Changing

$$a = v^2/r \quad v \text{ is constant (not changing)}$$

13. Consider the bucket swing from lab. Choose the correct free-body diagram for the instant when the bucket is at the top of its swing.



The Singapore Flyer is currently the world's tallest Ferris wheel with a diameter of 150 meters. A passenger on the Ferris wheel finds that one rotation takes 190 seconds to go all the way around.

14. What is the angular velocity of this Ferris wheel?

- a.  $0.005 \text{ rad/s}$
- ☒ b.  $0.033 \text{ rad/s}$
- c.  $0.75 \text{ rad/s}$
- d.  $2.5 \text{ rad/s}$
- e.  $190 \text{ rad/s}$

$$\omega = \frac{\Delta \theta}{\Delta t} = \frac{2\pi \text{ rad}}{190 \text{ s}} = 0.033 \text{ rad/s}$$

15. What is the period of the Singapore Flyer?

- a.  $0.005 \text{ s}$
- b.  $0.033 \text{ s}$
- c.  $0.75 \text{ s}$
- d.  $2.5 \text{ s}$
- ☒ e.  $190 \text{ s}$

16. Calculate Mercury's speed as it orbits around the sun.

- a.  $366 \text{ m/s}$
- b.  $2,950 \text{ m/s}$
- c.  $7,910 \text{ m/s}$
- d.  $29,700 \text{ m/s}$
- ☒ e.  $47,900 \text{ m/s}$



$$v = \sqrt{\frac{GM}{r}} = \sqrt{\frac{6.67 \times 10^{-11} \text{ N m}^2/\text{kg}^2 \cdot 1.99 \times 10^{30} \text{ kg}}{5.79 \times 10^{10} \text{ m}}} = 47,879 \text{ m/s}$$

17. Determine the acceleration due to gravity on Mercury.

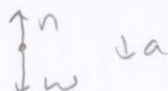
- a. 3.59 m/s<sup>2</sup>
- b. 3.77 m/s<sup>2</sup>
- c. 8.88 m/s<sup>2</sup>
- d. 9.8 m/s<sup>2</sup>
- e. 36.6 m/s<sup>2</sup>

$$mg = \frac{Gm_1m_2}{r^2}$$

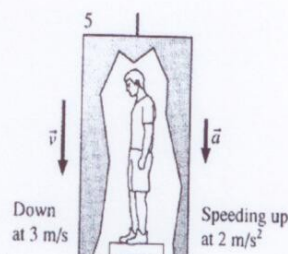
$$g = \frac{Gm}{r^2} = \frac{6.67 \times 10^{-11} \frac{\text{Nm}^2}{\text{kg}^2} \cdot 3.18 \times 10^{23} \text{ kg}}{(2.43 \times 10^6 \text{ m})^2} = 3.59 \text{ m/s}^2$$

18. A person is standing on a scale in an elevator as it moves. At the instant shown, the elevator is moving down at 3 m/s and is speeding up at 2 m/s<sup>2</sup>. What does the scale read in Newtons if the person has a mass of 80 kg?

- a. 476 N
- b. 546 N
- c. 624 N
- d. 784 N
- e. 826 N



$$\begin{aligned} n - w &= -ma \\ n &= w - ma \\ &= m(g - a) \\ &= 80 \text{ kg} (9.8 \text{ m/s}^2 - 2 \text{ m/s}^2) \\ &= 624 \text{ N} \end{aligned}$$



**You must show all work for credit on Problems 19 – 21**

19. Two children fight over a 200 g stuffed bear. The 25 kg boy pulls to the right with a 14 N force and the 20 kg girl pulls to the left with an 18 N force. Ignore all other forces on the bear (such as its weight). What is the magnitude and direction of its acceleration?

20. An 80kg person is on a Ferris wheel with a radius of 30 meters. The Ferris wheel is traveling at 0.35 radians per second.

- a. Draw a free body diagram when the person reaches the highest point in the ride.
- b. Apply Newton's second law (sum of forces) at the highest point.
- c. Determine the person's apparent weight as they reach the highest point.

21. A 25,000 kg semi's brakes fail as it heads down I-70. Luckily there's a runaway truck ramp nearby with a 10% grade. The semi enters the ramp at 30 m/s and goes up the ramp and the deep gravel quickly brings the truck to a stop in 3.0 s.

- a. Find the force of friction on the truck.
- b. Find the coefficient of friction between the gravel and tires.

$$G = 6.67 \times 10^{-11} \text{ Nm}^2/\text{kg}^2$$

$$T^2 = \frac{4\pi^2}{GM} r^3$$

$$v = \omega r$$

$$w = mg$$

$$v_x = \frac{\Delta x}{\Delta t} = \frac{x_f - x_i}{\Delta t}$$

$$x_f = x_i + v_{xi}\Delta t + \frac{1}{2} a_x(\Delta t)^2$$

$$\sin \theta = \text{opp/hyp}$$

$$F_G = \frac{Gm_1m_2}{r^2}$$

$$v = \frac{2\pi r}{T} = \sqrt{\frac{GM}{r}}$$

$$a = \frac{v^2}{r} = \omega^2 r$$

$$\Sigma \vec{F} = m\vec{a}$$

$$a_x = \frac{\Delta v_x}{\Delta t} = \frac{v_{xf} - v_{xi}}{\Delta t}$$

$$v_{xf} = v_{xi} + a_x \Delta t$$

$$\cos \theta = \text{adj/hyp}$$

$$1 \text{ radian} = 57.3^\circ$$

$$1000 \text{ g} = 1 \text{ kg}$$

$$f = \frac{1}{T}$$

$$g = 9.8 \text{ m/s}^2$$

$$v_{xf}^2 = v_{xi}^2 + 2a_x(\Delta x)$$

$$\tan \theta = \text{opp/adj} \quad a^2 + b^2 = c^2$$





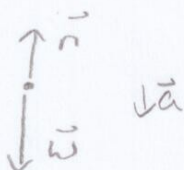
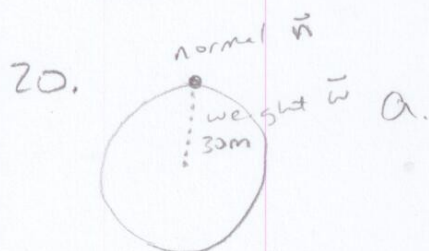
$$F_{\text{net}} = 14\text{N} - 18\text{N} = -4\text{N} \quad 2$$

$$F = ma$$

$$-4\text{N} = 0.200\text{kg} \cdot a \quad 4$$

$$|a = -20\text{m/s}^2|$$

Negative indicates that acceleration is to the left. 3



4

b.  $\Sigma F_y = n - w = -ma$  4

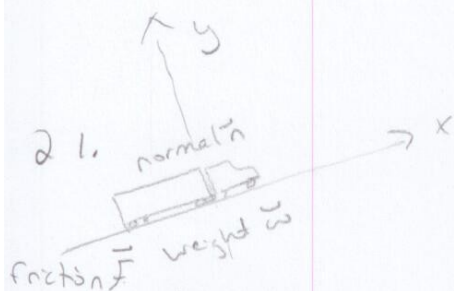
c.  $n = w - ma$

6  $= mg - ma$   
 $= m(g - a)$

$$= m(g - \omega^2 r) \quad \leftarrow -3$$

$$= 80\text{kg}(9.8\text{m/s}^2 - (0.35\text{rad/s})^2 30\text{m})$$

$$|F = 490\text{N}|$$



3  $\Sigma F_y = n - w \cos 10^\circ = 0$

$$\Sigma F_x = -f - w \sin 10^\circ = -ma$$

3 a.  $f = ma - w \sin 10^\circ$

$$= 25,000\text{kg}(10\text{m/s}^2 - 9.8\text{m/s}^2 \sin 10^\circ)$$

$$= |207,000\text{N}|$$

$$a = \frac{0\text{m/s} - 30\text{m/s}}{3.0\text{s}} \quad 2$$

$$= 10\text{m/s}^2$$

4 b.  $f = \mu n$

$$\mu = \frac{f}{n} = \frac{207,456\text{N}}{w \cos 10^\circ} = |0.86|$$