Physics 1,003, Fall 2016
Problem Set 2
8 problems; 46 points; estimated time: 1 hr.

1.(5) A block with a mass of 5 kg is pulled across a tabletop by a force of 10 N applied by a string tied to the end of the block. The table exerts a frictional force of 2 N on the block opposite to the direction of motion. What is the acceleration of the block?

1. (Answer, 5 points)

$$F = m \times a$$
$$F_{net} = F_{pull} - F_{friction} = m \times a$$
$$(10\ N) - (2\ N) = (5\ kg) \times a$$
$$a = \frac{8\ N}{5\ kg} = \frac{8\ kg \times m/s^2}{5\ kg}$$
$$a = 1.6\ m/s^2$$

2. (2) What is the difference between mass and weight?

2. (Answer, 2 points) Weight is the measure of the gravitational force acting on an object, while mass is an inherent property relating to the amount of matter comprising an object.

3. (3) If only two forces of equal magnitude act on an object in opposite directions, does the object accelerate? Could the object be moving?

3. (Answer, 3 points) The object cannot be accelerate given only two equal forces applied in opposite direction; however, the object could be moving with a constant velocity (or be stationary, with a constant velocity of zero).

4. (4) A tablecloth, when being pulled, exerts a frictional force of 0.6 N on a plate with a mass of 0.4 kg. What is the acceleration of the plate? In what direction?

4. (Answer, 4 points)

$$F = m \times a$$
$$(0.6\ N) = (0.4\ kg)$$
$$a = \frac{0.6\ N}{0.4\ kg} = \frac{0.6\ kg \times m/s^2}{0.4\ kg}$$
$$a = 1.5\ m/s^2$$

5. (10) A 60-kg person in an elevator is accelerating upwards at a rate of 1.2 m/s². (a) What is the net force acting upon the person? (b) What is the gravitational force acting upon the person? (c) What is the normal force pushing upwards on the person's feet?

5. (Answer, 10 points)

(a)

$$F_{net} = m \times a$$
$$F_{net} = (60\ kg) \times (1.2\ m/s^2)$$
$$F_{net} = 72\ N$$

(b)

$$F_g = m \times g$$
$$F_g = (60\ kg) \times (-9.8\ m/s^2)$$
$$F_g = -558\ N$$

(c)

$$F_{net} = \sum all\ forces$$
$$F_{net} = F_g + F_N$$
$$(72\ N) = (-558\ N) + F_N$$
$$F_N = 72\ N + 558\ N = 630\ N$$

6. (7) A 0.5-kg book rests on a table. A downward force of 6 N is exerted on the top of the book by a hand pushing down on the book. (a) What is the magnitude of the gravitational force acting upon the book? (b) What is the magnitude of the normal force exerted by the table on the book?

6. (Answer, 7 points)

(a)

$$F_g = m \times g$$
$$F_g = (0.5\ kg) \times (-9.8\ m/s^2)$$
$$F_g = -4.9\ N$$

(c)

$$Constant\ velocity: \sum F = 0\ N$$
$$(0\ N) = F_g + F_N + F_{hand}$$
$$(0\ N) = (-4.9\ N) + F_N + (-6\ N)$$
$$F_N = 4.9\ N + 6\ N = 10.9\ N$$

7. (6) A car with a mass of 1,200 kg is moving around a curve with a radius of 40 m at a constant speed of 20 m/s (approximately 45 mph). (a) What is the centripetal acceleration of the car? (b) what is the magnitude of the force required to produce this centripetal acceleration?

7. (Answer, 6 points)

(a)

$$a_c = \frac{v^2}{r}$$

$$a_c = \frac{(20\frac{m}{s})^2}{40\ m}$$

$$a_c = 10\ m/s^2$$

(b)

$$F_c = m \times a_c$$

$$F_c = (1{,}200\ kg) \times (10\frac{m}{s^2})$$

$$F_c = 12{,}000\ N\ towards\ center$$

8. (9) Colonel Murgatroyd has a weight of 720 N (about 162 lbs.) when he is standing on the surface of the Earth. (a) What would his weight (the gravitational force exerted by the Earth) be if he doubled his distance from the center of the Earth by flying a spacecraft? Use both F_g=mg and Newton's Universal Law of Gravitation, and take Earth's radius to be 6,371 km. (b) Compare the forces on the colonel and explain their ratio.

8. (Answer, 9 points)

(a)

Step 1: Find Col. Murgatroyd's mass.

$$F_g = m \times g$$

$$-720\ N = m \times (-9.8\ m/s^2)$$

$$m_{Col.Murgatroyd} = 73.5\ kg$$

Step 2: Find the force at the doubled distance.

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

$$F_G|_{doubled\ distance} = -\frac{Gm_{Col.Murgatroyd}m_{\oplus}}{(2r_{\oplus})^2}$$

$$F_G = -\frac{\left(6.67 \times 10^{-11}\ \frac{m^3}{kg \times s^2}\right) \times (73.5\ kg) \times (5.972 \times 10^{24} kg)}{(2 \times (6{,}371 \times 10^3\ m))^2}$$

$$F_G = -180.326\ N$$

(b)

Step 1: Comparison.

$$\frac{-180\ N}{-720\ N} = \frac{1}{4}$$

So, when we doubled the distance from the Earth, the colonel's weight was quartered.

Step 2: Consistency?

Newton's Universal Law of Gravitation is inversely proportional to the square of the distance between the two objects; so, if we double that distance, we quarter the force between them. Our answer is right.