



I'm not a robot



Open

UNIT  
**3** Circular Motion and Gravitation | 3.A Inertia and Acceleration

NAME \_\_\_\_\_

DATE \_\_\_\_\_

**Scenario**

*Angela is in a stopped car at a traffic light when the light turns green and she accelerates.*

**Using Representations**

PART A: Sketch and label vectors for velocity, acceleration, and net force on the car. (This is NOT a free-body diagram.)

Which way does Angela's body "feel" pushed? Explain in a short sentence why she feels this way.

She feels pushed \_\_\_\_\_ because \_\_\_\_\_

A simple line drawing of a car from a top-down perspective, showing the front grille, windows, and rear hatchback shape.

PART B: As she approaches a stop sign, she slams on the brakes. Sketch and label vectors for velocity, acceleration, and net force on the car. (This is NOT a free-body diagram.)

Which way does Angela's body "feel" pushed?

Which way is the car accelerating?

Which direction is the net force on the car?

A simple line drawing of a car from a top-down perspective, showing the front grille, windows, and rear hatchback shape.

PART C: As Angela continues driving, she rounds a corner at a constant speed. Sketch and label vectors for velocity, acceleration, and net force on the car. (This is NOT a free-body diagram.)

A line drawing of a car from a side-front perspective as it turns a sharp corner to the right. The road curves away from the viewer.

Which way does Angela's body "feel" pushed?

Which way is the car accelerating?

Which direction is the net force on the car?

## Central Net Force Model Worksheet 4: Orbital Motion

1. Suppose you are at mission control on the moon, in charge of launching a moon-orbiting communications satellite.

a. First, how much would a 1500 kg satellite weigh at the surface of the moon? (The gravitational field strength on Earth's moon is 1.6 m/s<sup>2</sup>, or 1.6 N/kg.)

$$F_g = mg$$

$$(g_{\text{on moon}} = 1.6 \text{ m/s}^2)$$

$$F_g = 1.6 \text{ m/s}^2 \times (m = 1500 \text{ kg})$$

$$F_g = 2400 \text{ N}$$

b. The satellite is to have an altitude of 100 km above the moon's surface. What is the radius of the orbit of the satellite? (The radius of the moon is  $1.74 \times 10^6$  m.)

$$r = 1.74 \times 10^6 \text{ m}$$

$$r + h = 1.84 \times 10^6$$

$$h = 100 \text{ km}$$

$$h = 100,000 \text{ m}$$

c. Find the required orbital velocity for the satellite. (the moon's mass is  $7.36 \times 10^{22}$  kilograms)

$$\text{mass moon} = 7.36 \times 10^{22}$$

$$v = \sqrt{\frac{GM}{r}}$$

$$\text{mass satellite} = 1500 \text{ kg}$$

$$F = \frac{G m_1 m_2}{r^2}$$

$$r = 1.84 \times 10^6$$

$$G = 6.673 \times 10^{-11}$$

$$v = \sqrt{r \cdot \frac{GM}{r^2}}$$

d. How long will it take the satellite to orbit the moon? (This time is called the orbital period.)

$$r = 1.84 \times 10^6 \text{ m}$$

$$c = 2\pi r$$

$$v = \frac{c}{T}$$

$$t = \frac{2\pi r}{v}$$

$$t = \frac{2\pi r}{1634}$$

$$T = 7075 \text{ sec}$$

$$T = 1.96 \text{ hours}$$

e. Is this satellite accelerating while in orbit? If so, what is the direction and magnitude of the acceleration?

yes, it is changing directions! It's going towards the center.  $\frac{v^2}{r} = a$   $\frac{1634^2}{1.84 \times 10^6} = 1.45 \text{ m/s}^2$

2. The international space station orbits the earth at speed of approximately 17,000 mph at a height of over 200 miles.

a. Why do astronauts appear to "float" aboard the international space station?

b. What sensation does an astronaut feel while in orbit?

c. Are astronauts in orbit really "weightless"? What might be a better description?

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Central Force Model ws4 v2.1

1. What is the difference between electronegativity and ionization energy?
  2. Why does fluorine have a higher ionization energy than iodine?
  3. Why do elements in the same family generally have similar properties?
  4. Which is the largest atom in Group 4a (14)?
  5. Which is the smallest atom in Group 7a (17)?
  6. Which is the smallest atom in period 5?
  7. Rank the following elements by increasing atomic radius: carbon, aluminum, oxygen, potassium.
  8. Rank the following elements by increasing electronegativity: sulfur, oxygen, neon, aluminum.
  9. Arrange the following atoms in order of decreasing atomic radius. Na Al P Cl Mg
  10. For each of the following pairs, circle the element that is larger?  
a. Sulfur or Chlorine  
b. Phosphorus or Nitrogen  
c. Boron or Carbon  
d. Potassium or Sodium  
e. Oxygen or Neon  
f. Magnesium or Aluminum

11. Circle the element in each pair has the larger radius?  
a) Mg or  $Mg^{2+}$       b)  $\Omega$  or  $\Omega^{2-}$       c)  $K^+$  or  $K$

12. In each of the following pairs, circle the species with the higher first ionization energy:

(a) Li or Ca (b) Cl or Ar (c) Ge or Br (d) N or Ne (e) P or Br

13. In each of the following pairs, circle the species with the *larger* atomic radius:

  - a) Mg or Ba    b) S or  $S^{2-}$     c)  $Cu^{+2}$  or Cu    d) He or H    e) Na or Cl

14. Circle the best choice in each list:

- a) highest *first* ionization energy: C, N, Si
  - b) highest electronegativity: As, Sn, S
  - c) largest radius:  $S^{2-}$ ,  $Cl^-$ , Cl

15. Order the following groups from largest to smallest radii.

- a) Ar, Cl<sup>-</sup>, K, S<sup>2-</sup>
  - b) C, Al, F, Si
  - c) Na, Mg, Ar, P
  - d) F<sup>-</sup>, Ba<sup>2+</sup>, Cs<sup>+</sup>, F<sup>-</sup>



SOLUTIONS TO CONCEPTS circular motion:  
CHAPTER 7

- Distance between Earth & Moon  
 $r = 3.85 \times 10^5 \text{ km} = 3.85 \times 10^8 \text{ m}$   
 $T = 27.3 \text{ days} = 24 \times 3600 \times (27.3) \text{ sec} = 2.36 \times 10^7 \text{ sec}$   
 $v = \frac{2\pi r}{T} = \frac{2 \times 3.14 \times 3.85 \times 10^8}{2.36 \times 10^7} = 1029.42 \text{ m/sec}$   
 $a = \frac{v^2}{r} = \frac{(1029.42)^2}{3.85 \times 10^8} = 0.00273 \text{ m/sec}^2 = 2.73 \times 10^{-3} \text{ m/sec}^2$
  - Diameter of earth = 12800km  
Radius  $R = 6400 \text{ km} = 64 \times 10^6 \text{ m}$   
 $v = \frac{2\pi R}{T} = \frac{2 \times 3.14 \times 64 \times 10^6}{24 \times 3600} \text{ m/sec} = 465.185$   
 $a = \frac{v^2}{R} = \frac{(465.185)^2}{64 \times 10^6} = 0.0336 \text{ m/sec}^2$
  - $V = 2\pi r$ ,  $r = 1 \text{ cm}$   
a) Radial acceleration at  $t = 1 \text{ sec}$ .  
 $a = \frac{v^2}{r} = \frac{2^2}{1} = 4 \text{ cm/sec}^2$   
b) Tangential acceleration at  $t = 1 \text{ sec}$ .  
 $a = \frac{dv}{dt} = \frac{d(2t)}{dt} = 2 \text{ cm/sec}^2$   
c) Magnitude of acceleration at  $t = 1 \text{ sec}$   
 $a = \sqrt{4^2 + 2^2} = \sqrt{20} \text{ cm/sec}^2$
  - Given that  $m = 150 \text{ kg}$ ,  
 $v = 36 \text{ km/hr} = 10 \text{ m/sec}$ ,  $r = 30 \text{ m}$   
Horizontal force needed is  $\frac{mv^2}{r} = \frac{150 \times (10)^2}{30} = \frac{150 \times 100}{30} = 500 \text{ N}$
  - In the diagram  
 $R \cos \theta = mg \quad \dots(i)$   
 $R \sin \theta = \frac{mv^2}{r} \quad \dots(ii)$   
Dividing equation (i) with equation (ii)  
 $\tan \theta = \frac{\frac{mv^2}{r}}{mg} = \frac{v^2}{rg}$   
 $v = 36 \text{ km/hr} = 10 \text{ m/sec}$ ,  $r = 30 \text{ m}$   
 $\tan \theta = \frac{v^2}{rg} = \frac{100}{30 \times 10} = (1/3)$   
 $\Rightarrow \theta = \tan^{-1}(1/3)$
  - Radius of Park =  $r = 10 \text{ m}$   
speed of vehicle =  $18 \text{ km/hr} = 5 \text{ m/sec}$   
Angle of banking  $\tan \theta = \frac{v^2}{rg}$   
 $\Rightarrow \theta = \tan^{-1} \frac{v^2}{rg} = \tan^{-1} \frac{25}{25} = \tan^{-1}(1/4)$

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