Name: Date:

Study Guide for Circular Motion and Momentum

TOPICS

1. **CENTRIPETAL MOTION:**
   a. **Centripetal Acceleration (a_c):**

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

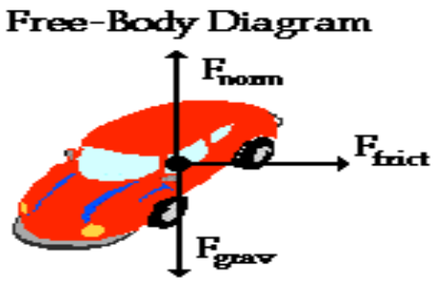
   b. **Centripetal Force (F_c):**

$$F_{net} = F_c$$

$$F_c = ma_c = m\frac{v^2}{r}$$

Newton's Second Law Equations

$$a = \frac{F_{net}}{m} \qquad F_{net} = m * a$$



2. **UNIVERSAL GRAVITATION:**
   a. **Newton's Law of Universal Gravitation:**

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

      i. Gravitational force is **directly proportional** to the masses of both objects
      ii. Gravitational force is **inversely proportional** to the distance between the objects

   b. **Gravitational Fields**

$$g = \frac{GM}{r^2} \quad \textit{OR} \quad g = \frac{F}{m}$$

      i. Objects with mass create an invisible disturbance in the space around them that is felt by other massive objects.
      ii. Gravitational field strength is a vector quantity

   c. **Gravitational Orbits:**
      i. Since gravity provides the centripetal force for a satellite in orbit:

$$F_c = F_g$$

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

      ii. **Orbital Velocity (v):**

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

      iii. **Orbital Period (T):**

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

3. **MOMENTUM (p):**
   a. Mass in motion. "How difficult it is to stop an object":

$$p = mv$$

   b. **Impulse-Momentum Theorem -** When an object experiences a force, the object experiences a change in momentum
      i. The change in momentum of an object is equal to the force acting on it multiplied by the time over which this force acts on the object.

$$J = \Delta p = m\Delta v$$

$$Ft = m\Delta v$$

      ii. **Impulse (J = Ft) –** Change in momentum

   c. **Conservation of Momentum**
      i. **Collisions -** Total momentum of the system before the collision is equal to the total momentum of the system after the collision.

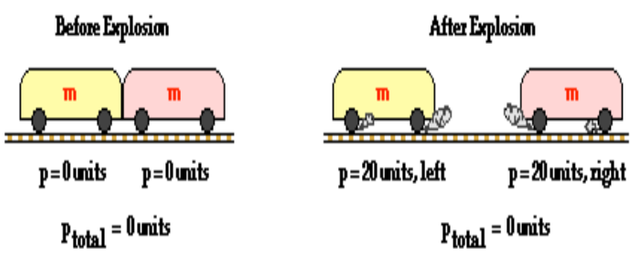
$$p_{before} = p_{after}$$

         1. Inelastic – objects stick together
         2. Elastic – objects do not stick together

      ii. **Explosions -** Total momentum after explosion = total momentum before explosion. Just like in collisions, total system momentum is conserved.
         1. Total momentum before and after an explosion is typically equal to 0.

ADDITIONAL REVIEW:

a. Class Website: www.julianncal.wix.com/mscalabrese
b. Castle Learning: www.castlelearning.com
c. Physics Classroom: www.physicsclassroom.com



1. Which object has the greatest inertia?

   A) a 0.010-kg bullet traveling at 90. m/s
   B) a 30.-kg child traveling at 10. m/s on her bike
   C) a 490-kg elephant walking with a speed of 1.0 m/s
   D) a 1500-kg car at rest in a parking lot

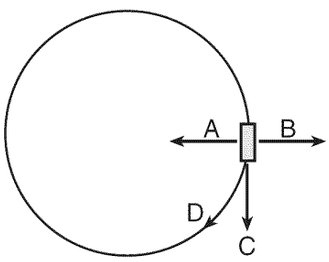
2. If the magnitude of the gravitational force of Earth on the Moon is *F*, the magnitude of the gravitational force of the Moon on Earth is

   A) smaller than *F* B) larger than *F*
   C) equal to *F*

3. A 1.0×10^3-kilogram car travels at a constant speed of 20. meters per second around a horizontal circular track. The diameter of the track is 1.0×10^2meters. The magnitude of the car's centripetal acceleration is

   A) $0.20\,\mathrm{m/s^2}$ B) $2.0\,\mathrm{m/s^2}$
   C) $8.0\,\mathrm{m/s^2}$ D) $4.0\,\mathrm{m/s^2}$

4. In the diagram below, a cart travels clockwise at constant speed in a horizontal circle.



   At the position shown in the diagram, which arrow indicates the direction of the centripetal acceleration of the cart?

   A) *A* B) *B* C) *C* D) *D*

5. A 1750-kilogram car travels at a constant speed of 15.0 meters per second around a horizontal, circular track with a radius of 45.0 meters. The magnitude of the centripetal force acting on the car is

   A) 5.00 N B) 583 N
   C) 8750 N D) 3.94×10^5 N

6. The magnitude of the centripetal force acting on an object traveling in a horizontal, circular path will *decrease* if the

   A) radius of the path is increased
   B) mass of the object is increased
   C) direction of motion of the object is reversed
   D) speed of the object is increased

7. If the mass of one of two objects is increased, the force of attraction between them will

   A) decrease B) increase
   C) remain the same

8. If the distance between two masses were tripled, the gravitational force between them would be

   A) 1/9 as great B) 1/3 as great
   C) 3 times as great D) 9 times as great

9. What is the speed of a 1.0×10^3-kilogram car that has a momentum of 2.0×10^4 kilogram • meters per second east?

   A) 5.0×10^{-2} m/s B) 2.0×10^1 m/s
   C) 1.0×10^4 m/s D) 2.0×10^7 m/s

10. Two cars having different weights are traveling on a level surface at different constant velocities. Within the same time interval, greater force will always be required to stop the car that has greater

    A) weight B) kinetic energy
    C) velocity D) momentum

11. A mother pushes her 120-newton child, who is sitting on a swing. If the mother exerts a 10.-newton force on the child for 0.50 second, what is the magnitude of the impulse imparted to the child by the mother?

    A) 5.0 N•s B) 20. N/s
    C) 60. N•s D) 240 N/s

12. When a 1.0-kilogram cart moving with a speed of 0.50 meter per second on a horizontal surface collides with a second 1.0-kilogram cart initially at rest, the carts lock together. What is the speed of the combined carts after the collision? [Neglect friction.]

    A) 1.0 m/s B) 0.50 m/s
    C) 0.25 m/s D) 0 m/s

13. A 20-kilogram cart traveling east with a speed of 6 meters per second collides with a 30-kilogram cart traveling west. If both carts come to rest immediately after the collision, what was the speed of the westbound cart before the collision?

    A) 6 m/s B) 2 m/s C) 3 m/s D) 4 m/s

14. Which object has the greatest momentum?

    A) a 12-kg mass moving at 1 m/sec
    B) a 5-kg mass moving at 2 m/sec
    C) a 9-kg mass moving at 3 m/sec
    D) a 4-kg mass moving at 4 m/sec

15. What is the momentum of a 1.5×10^3-kilogram car as it travels at 30. meters per second due east for 60. seconds?

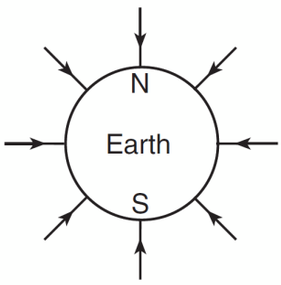
    A) 4.5×10^4 kg•m/s, east
    B) 4.5×10^4 kg•m/s, west
    C) 4.5×10^6 kg•m, east
    D) 4.5×10^6 kg•m, west

16. The centers of two 15.0-kilogram spheres are separated by 3.00 meters. The magnitude of the gravitational force between the two spheres is approximately

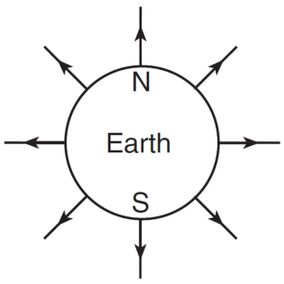
    A) 1.11×10^{-10} N B) 3.34×10^{-10} N
    C) 1.67×10^{-9} N D) 5.00×10^{-9} N

17. In which diagram do the field lines best represent the gravitational field around Earth?

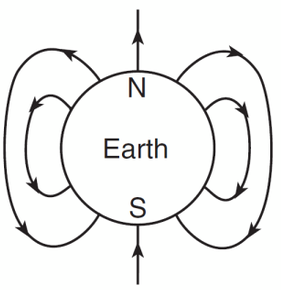
A)



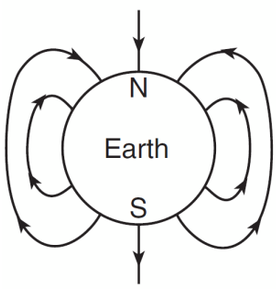
B)



C)

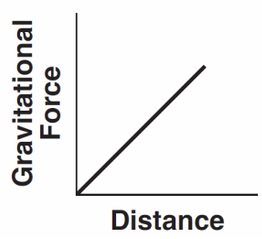


D)



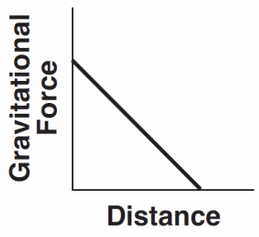
18. Which graph represents the relationship between the magnitude of the gravitational force exerted by Earth on a spacecraft and the distance between the center of the spacecraft and center of Earth? [Assume constant mass for the spacecraft.]

A)



B)

C)



D)

19. A 3.1 kilogram gun initially at rest is free to move. When a 0.015-kilogram bullet leaves the gun with a speed of 500. meters per second, what is the speed of the gun?

A) 0.0 m/s B) 2.4 m/s
C) 7.5 m/s D) 500. m/s

20. A 4.0-kilogram mass is moving at 3.0 meters per second toward the right and a 6.0-kilogram mass is moving at 2.0 meters per second toward the left on a horizontal frictionless table. If the two masses collide and remain together after the collision, their final momentum is

A) 1.0 kg-m/s B) 24 kg-m/s
C) 12 kg-m/s D) 0 kg-m/s

21. A 0.149-kilogram baseball, initially moving at 15 meters per second, is brought to rest in 0.040 second by a baseball glove on a catcher's hand. The magnitude of the average force exerted on the ball by the glove is

A) 2.2 N B) 2.9 N C) 17 N D) 56 N

22. Which object has the greatest inertia?

A) a 15-kg mass traveling at 5.0 m/s
B) a 10.-kg mass traveling at 10. m/s
C) a 10.-kg mass traveling at 5.0 m/s
D) a 5.0-kg mass traveling at 15 m/s

23. Base your answer to the following question on the information below.

A 1200-kilogram car moving at 12 meters per second collides with a 2300-kilogram car that is waiting at rest at a traffic light. After the collision, the cars lock together and slide. Eventually, the combined cars are brought to rest by a force of kinetic friction as the rubber tires slide across the dry, level, asphalt road surface.

Calculate the speed of the locked-together cars immediately after the collision. [Show all work, including the equation and substitution with units.]

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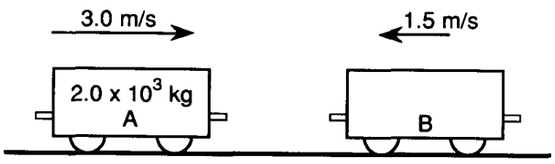
24. Calculate the magnitude of the impulse applied to a 0.75-kilogram cart to change its velocity from 0.50 meter per second east to 2.00 meters per second east. [Show all work, including the equation and substitution with units.]

25. Base your answers to parts a through c on the diagram and information below.

Two railroad carts, A and B, are on a frictionless, level track. Cart A has a mass of 2.0×10^3 kilograms and a velocity of 3.0 meters per second toward the right. Cart B has a velocity of 1.5 meters per second toward the left. The magnitude of the momentum of cart B is 6.0×10^3 kilogram-meters per second. When the two carts collide, they lock together.



a

What is the magnitude of the momentum of cart A before the collision? (Show all calculations, including equations and substitutions with units.)

b

Below the drawing of Cart A, construct a scaled vector that represents the momentum of cart A before the collision. The momentum vector must be drawn to a scale of 1.0 centimeter = 1,000 kilogram-meters per second. Be sure your final answer appears with correct labels (numbers and units).

c

In one or more complete sentences, describe the momentum of the two carts after the collision and justify your answer based on the initial momenta of both carts.