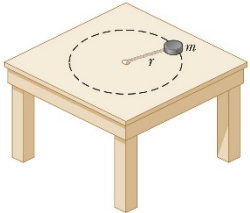


## University Physics I

### Homework Set 12

1. A light string can support a stationary hanging load of  $25.0\text{ kg}$  before breaking. An object of mass  $m = 3.00\text{ kg}$  attached to the string rotates on a frictionless, horizontal table in a circle of radius  $0.800\text{ m}$ . The other end of the string is held in place the center of the table in such a way that allows to spin without friction as shown at right. What is the maximum tangential speed that the object can have before the string breaks?
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- The diagram shows a square table with four legs. On the top surface of the table, a dashed circle represents the path of rotation. A string is attached to the center of the table and extends to a small grey mass labeled 'm'. The mass is positioned on the dashed circle. A small arrow indicates the direction of rotation.
2. Whenever two Apollo astronauts were on the surface of the Moon, a third astronaut orbited the Moon at an altitude of  $100\text{ km}$  above the surface. The acceleration due to the gravity of the Moon is  $1.52\text{ m/s}^2$  and the radius of the Moon is  $1.74 \times 10^6\text{ m}$ . Assuming the orbit around the Moon as circular, determine:
    - a. The orbiting astronaut's orbital speed
    - b. The period of the orbit
  3. What is the angle (*in degrees*) that the Earth sweeps out during the month of November? Assume the orbit of the Earth is circular.
  4. A baseball is thrown at  $88.0\text{ mph}$  and with a spin rate of  $2200\text{ rpm}$ . If the distance between the pitcher's point of release and the catcher's glove is  $60.5\text{ ft}$ , how many full rotations does the ball make between release and catch? Neglect any effect of gravity or air resistance on the ball during flight.
  5. In the Bohr model of the hydrogen atom, an electron moves in a circular orbit around the proton. The speed of the electron is approximately  $2.20 \times 10^6\text{ m/s}$  orbiting at a radius of  $0.529 \times 10^{-10}\text{ m}$ . (*Note: This radius for the ground state electron in hydrogen is often called the Bohr radius*). Find:
    - a. The magnitude of the force acting on the electron as it revolves around the proton
    - b. The centripetal acceleration of the electron
    - c. What is the direction of the force and centripetal acceleration?
  6. What is the centripetal acceleration of the Moon as it rotates about the Earth if its period of rotation is  $27.3$  days? The radius of the Moon's orbit is  $3.85 \times 10^8\text{ m}$ .
  7. A  $52\text{ kg}$  ice skater spins about a vertical axis that is imagined running through her body with her arms horizontally outstretched. She makes  $2.0$  turns each second. The distance from one hand to the other is  $1.50\text{ m}$ . Biometric measurements indicate that each hand typically makes up about  $1.25\%$  of the body's total weight.
    - a. Draw a force diagram of one of the skater's hands
    - b. What is the magnitude of the horizontal force the wrist exerts on the hand during the spin?
  8. Life scientists use centrifuges to separate biological components or to remove molecules from suspension. Samples in a symmetric array of containers are spun rapidly about a central axis. The centrifugal acceleration they experience in their moving reference frame acts as an "artificial gravity" to effect a rapid separation. If the sample containers are  $10.0\text{ cm}$  from the rotation axis, what rotation frequency (*in rpm*) is required to produce an acceleration of  $1.00 \times 10^5\text{ g}$ 's?

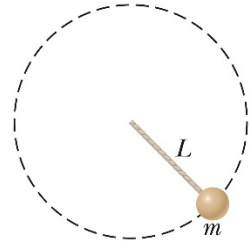
9. A conical pendulum with a bob of mass  $m = 80.0 \text{ kg}$  on a string of length  $L = 10.0 \text{ m}$  makes an angle of  $5.00^\circ$  with the vertical as shown in the figure at right. Determine:
- The horizontal and vertical components of the force exerted by the string on the bob.
  - The magnitude of the radial acceleration of the bob. What direction is this acceleration?



10. A coin is placed 30.0 cm from the center of a rotating, horizontal turntable slips when its tangential speed is 50.0 cm/s. What is the coefficient of static friction between the coin and the turntable?

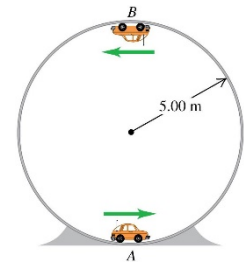
11. A ball of mass  $0.275 \text{ kg}$  swings in a vertical circular path on a string with a length of  $0.850 \text{ m}$  as shown in the figure at right.

- Draw a force diagram for the ball when it is at the top and at the bottom of the circle.
- If its speed is  $5.20 \text{ m/s}$  at the top of the circle, what is the tension in the string at that moment?
- If the string breaks when its tension exceeds  $25 \text{ N}$ , what is the maximum speed that ball can have at the bottom before that happens?



12. A small remote-controlled car with mass  $1.60 \text{ kg}$  moves at a constant speed of  $v = 12.0 \text{ m/s}$  in a track formed by a vertical circle inside a hollow metal cylinder that has a radius of  $5.00 \text{ m}$  as shown in the figure at right.

- What is the magnitude of the Normal force exerted on the car by the wall at point A?
- What is the magnitude of the Normal force exerted on the car by the wall at point B?



13. The Cosmo Clock 21 Ferris wheel in Yokohama, Japan, has a diameter of  $100 \text{ m}$ . Its name comes from its 60 arms, each of which can function as a second hand (*so that it makes one revolution every 60.0 s*).

- Find the orbital speed  $v$  of the passengers when the Ferris wheel is rotating at this rate, assuming they sit at the outer edge of the Ferris wheel.
- What would be the orbital speed  $v$  and the period for one revolution if the passenger's apparent weight (*as measured by the Normal force*) at the highest point were zero?



14. A crate of eggs is located in the middle of the flatbed of a pickup truck as the truck negotiates a curve in a flat stretch of road. The curve may be regarded as an arc of a circle of radius  $35.0 \text{ m}$ . If the coefficient of static friction between the crate and the truck is  $0.600$ , how fast can the truck be moving without the crate sliding?

15. A flat (unbanked) curve on a highway has a radius of  $170.0\text{ m}$ . A car rounds the curve at a speed of  $25.0\text{ m/s}$ .
- What is the minimum coefficient of static friction that will prevent sliding?
  - Suppose that highway is icy and the coefficient of static friction between the tires and the pavement is  $1/3$  of the value you found in part (a). What should the maximum speed of the car be so that it can round the curve safely?
16. A  $1125\text{ kg}$  car approaches a curve on a highway that has a radius of  $225\text{ m}$ .
- At what angle (*in degrees*) should the highway engineer bank this curve so that the vehicle traveling at  $65\text{ mph}$  can safely round it regardless of the condition of its tires?
  - Does a  $2250\text{ kg}$  pickup truck need to go faster, slower or the same speed as the car to make the curve under the same conditions?
  - As the car and truck round the curve at  $65\text{ mph}$ , find the normal force on each vehicle due to the highway surface.