PH 201 Homework Assignment Chapter on Rotational Kinematics – 30 Problems Total

1. A pitcher throws a curveball that reaches the catcher in 0.60 s. The ball curves because it is spinning at an average angular velocity of 330 rev/min (assumed constant) on its way to the catcher's mitt. What is the angular displacement of the baseball (in radians) as it travels from the pitcher to the catcher?

Solution for Problem 1

2. The earth spins on its axis once a day and orbits the sun once a year (365.25 days). Determine the average angular velocity (in rad/s) of the earth as it **(a)** spins on its axis and **(b)** orbits the sun. In each case, take the positive direction for the angular displacement to be the direction of the earth's motion.

Solution for Problem 2

3. Our sun rotates in a circular orbit about the center of the Milky Way galaxy. The radius of the orbit is 2.2×10^{20} m, and the angular speed of the sun is 1.1×10^{-15} rad/s. How long (in years) does it take for the sun to make one revolution around the center?

Solution for Problem 3

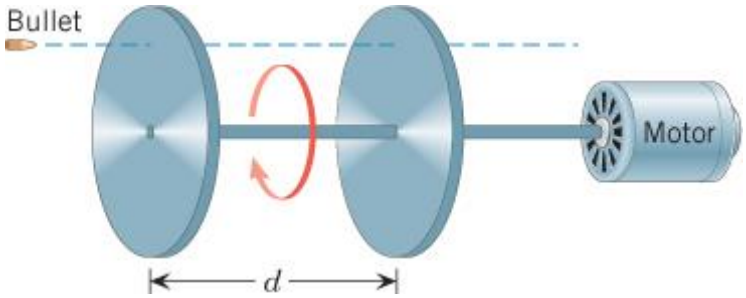
4. A Ferris wheel rotates at an angular velocity of 0.24 rad/s. Starting from rest, it reaches its operating speed with an average angular acceleration of 0.030 rad/s^2. How long does it take the wheel to come up to operating speed?

Solution for Problem 4

5. Two people start at the same place and walk around a circular lake in opposite directions. One walks with an angular speed of 1.7×10^{-3} rad/s, while the other has an angular speed of 3.4×10^{-3} rad/s. How long will it be before they meet?

Solution for Problem 5

6. The drawing shows a device that can be used to measure the speed of a bullet. The device consists of two rotating disks, separated by a distance of d = 0.850 m, and rotating with an angular speed of 95.0 rad/s. The bullet first passes through the left disk and then through the right disk. It is found that the angular displacement between the two bullet holes is θ = 0.240 rad. From these data, determine the speed of the bullet.



Solution for Problem 6

7. A stroboscope is a light that flashes on and off at a constant rate. It can be used to illuminate a rotating object, and if the flashing rate is adjusted properly, the object can be made to appear stationary. **(a)** What is the shortest time between flashes of light that will make a three-bladed propeller appear stationary when it is rotating with an angular speed of 16.7 rev/s? **(b)** What is the next shortest time?

Solution for Problem 7

8. A figure skater is spinning with an angular velocity of +15 rad/s. She then comes to a stop over a brief period of time. During this time, her angular displacement is +5.1 rad. Determine **(a)** her average angular acceleration and **(b)** the time during which she comes to rest.

Solution for Problem 8

9. A gymnast is performing a floor routine. In a tumbling run she spins through the air, increasing her angular velocity from 3.00 to 5.00 rev/s while rotating through one-half of a revolution. How much time does this maneuver take?

Solution for Problem 9

10. The wheels of a bicycle have an angular velocity of +20.0 rad/s. Then, the brakes are applied. In coming to rest, each wheel makes an angular displacement of +15.92 revolutions. **(a)** How much time does it take for the bike to come to rest? **(b)** What is the angular acceleration (in rad/s^2) of each wheel?

Solution for Problem 10

11. A dentist causes the bit of a high-speed drill to accelerate from an angular speed of 1.05 x 10^4 rad/s to an angular speed of 3.14 x 10^4 rad/s. In the process, the bit turns through 1.88 x 10^4 rad. Assuming a constant angular acceleration, how long would it take the bit to reach its maximum speed of 7.85 x 10^4 rad/s, starting from rest?

Solution for Problem 11

12. A top is a toy that is made to spin on its pointed end by pulling on a string wrapped around the body of the top. The string has a length of 64 cm and is wound around the top at a spot where its radius is 2.0 cm. The thickness of the string is negligible. The top is initially at rest. Someone pulls the free end of the string, thereby unwinding it and giving the top an angular acceleration of +12 rad/s^2. What is the final angular velocity of the top when the string is completely unwound?

Solution for Problem 12

13. The drive propeller of a ship starts from rest and accelerates at 2.90 x 10^{-3} rad/s^2 for 2.10 x 10^3 s. For the next 1.40 x 10^3 s the propeller rotates at a constant angular speed. Then it decelerates at 2.30 x 10^{-3} rad/s^2 until it slows (without reversing direction) to an angular speed of 4.00 rad/s. Find the total angular displacement of the propeller.

Solution for Problem 13

14. At the local swimming hole, a favorite trick is to run horizontally off a cliff that is 8.3 m above the water. One diver runs off the edge of the cliff, tucks into a "ball," and rotates on the way down with an average angular speed of 1.6 rev/s. Ignore air resistance and determine the number of revolutions she makes while on the way down.

Solution for Problem 14

15. A fan blade is rotating with a constant angular acceleration of +12.0 rad/s^2. At what point on the blade, as measured from the axis of rotation, does the magnitude of the tangential acceleration equal that of the acceleration due to gravity?

Solution for Problem 15

16. Some bacteria are propelled by biological motors that spin hairlike flagella. A typical bacterial motor turning at a constant angular velocity has a radius of 1.5 x 10^{-8} m, and a tangential speed at the rim of 2.3 x 10^{-5} m/s. **(a)** What is the angular speed (the magnitude of the angular velocity) of this bacterial motor? **(b)** How long does it take the motor to make one revolution?

Solution for Problem 16

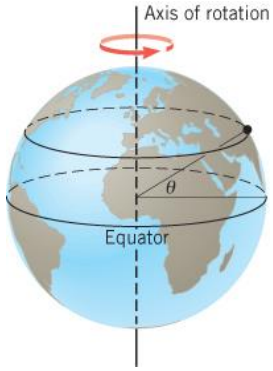
17. A string trimmer is a tool for cutting grass and weeds; it utilizes a length of nylon "string" that rotates about an axis perpendicular to one end of the string. The string rotates at an angular speed of 47 rev/s, and its tip has a tangential speed of 54 m/s. What is the length of the rotating string?

Solution for Problem 17

18. In 9.5 s a fisherman winds 2.6 m of fishing line onto a reel whose radius is 3.0 cm (assumed to be constant as an approximation). The line is being reeled in at a constant speed. Determine the angular speed of the reel.

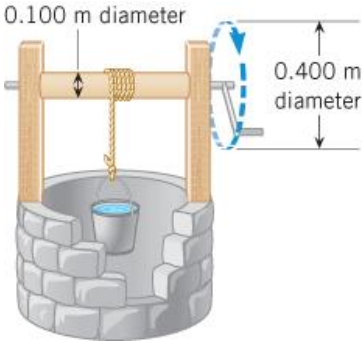
Solution for Problem 18

19. The earth has a radius of 6.38 x 10^6 m and turns on its axis once every 23.9 h. **(a)** What is the tangential speed (in m/s) of a person living in Ecuador, a country that lies on the equator? **(b)** At what latitude (i.e., the angle θ in the drawing) is the tangential speed one-third that of a person living in Ecuador?



Solution for Problem 19

20. A person lowers a bucket into a well by turning the hand crank, as the drawing illustrates. The crank handle moves with a constant tangential speed of 1.20 m/s on its circular path. The rope holding the bucket unwinds without slipping on the barrel of the crank. Find the linear speed with which the bucket moves down the well.



Solution for Problem 20

21. A thin rod (length = 1.50 m) is oriented vertically, with its bottom end attached to the floor by means of a frictionless hinge. The mass of the rod may be ignored, compared to the mass of an object fixed to the top of the rod. The rod, starting from rest, tips over and rotates downward. **(a)** What is the angular speed of the rod just before it strikes the floor? *(Hint: Consider using the principle of conservation of mechanical energy.)* **(b)** What is the magnitude of the angular acceleration of the rod just before it strikes the floor?

Solution for Problem 21

22. Two Formula One racing cars are negotiating a circular turn, and they have the same centripetal acceleration. However, the path of car A has a radius of 48 m, while that of car B is 36 m. Determine the ratio of the angular speed of car A to the angular speed of car B.

Solution for Problem 22

23. The earth orbits the sun once a year (3.16×10^7 s) in a nearly circular orbit of radius 1.50×10^{11} m. With respect to the sun, determine **(a)** the angular speed of the earth, **(b)** the tangential speed of the earth, and **(c)** the magnitude and direction of the earth's centripetal acceleration.

Solution for Problem 23

24. The sun has a mass of 1.99×10^{30} kg and is moving in a circular orbit about the center of our galaxy, the Milky Way. The radius of the orbit is 2.3×10^4 light-years
(1 light-year = 9.5×10^{15} m), and the angular speed of the sun is 1.1×10^{-15} rad/s.
(a) Determine the tangential speed of the sun. **(b)** What is the magnitude of the net force that acts on the sun to keep it moving around the center of the Milky Way?

Solution for Problem 24

25. A motorcycle accelerates uniformly from rest and reaches a linear speed of 22.0 m/s in a time of 9.00 s. The radius of each tire is 0.280 m. What is the magnitude of the angular acceleration of each tire?

Solution for Problem 25

26. A car is traveling with a speed of 20.0 m/s along a straight horizontal road. The wheels have a radius of 0.300 m. If the car speeds up with a linear acceleration of 1.50 m/s^2 for 8.00 s, find the angular displacement of each wheel during this period.

Solution for Problem 26

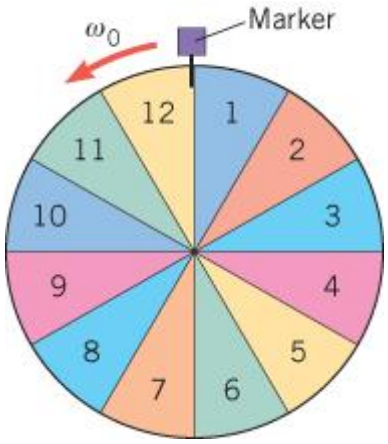
27. A dragster starts from rest and accelerates down a track. Each tire has a radius of 0.320 m and rolls without slipping. At a distance of 384 m, the angular speed of the wheels is 288 rad/s. Determine **(a)** the linear speed of the dragster and **(b)** the magnitude of the angular acceleration of its wheels.

Solution for Problem 27

28. A ball of radius 0.200 m rolls with a constant linear speed of 3.60 m/s along a horizontal table. The ball rolls off the edge and falls a vertical distance of 2.10 m before hitting the floor. What is the angular displacement of the ball while the ball is in the air?

Solution for Problem 28

29. At a county fair there is a betting game that involves a spinning wheel. As the drawing shows, the wheel is set into rotational motion with the beginning of the angular section labeled "1" at the marker at the top of the wheel. The wheel then decelerates and eventually comes to a halt on one of the numbered sections. The wheel in the drawing is divided into twelve sections, each of which is an angle of 30.0°. Determine the numbered section on which the wheel comes to a halt when the deceleration of the wheel has a magnitude of 0.200 rev/s^2 and the initial angular velocity is **(a)** +1.20 rev/s and **(b)** +1.47 rev/s.



Solution for Problem 29

30. Take two quarters and lay them on a table. Press down on one quarter so it cannot move. Then, starting at the 12:00 position, roll the other quarter along the edge of the stationary quarter, as the drawing suggests. How many revolutions does the rolling quarter make when it travels once around the circumference of the stationary quarter? Surprisingly, the answer is *not* one revolution.

Solution for Problem 30

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