10 The Vector Description of Rotational Motion

11 Angular Momentum

31. For each vector pair \( \vec{A} \) and \( \vec{B} \) shown below, determine if \( \vec{A} \times \vec{B} \) points into the page, out of the page, or is zero.

\[ \vec{A} \times \vec{B} \quad \vec{A} \times \vec{B} \quad \vec{A} \times \vec{B} \quad \vec{A} \times \vec{B} \]

32. Each figure below shows \( \vec{A} \) and \( \vec{A} \times \vec{B} \). Determine if \( \vec{B} \) is in the plane of the page or perpendicular to the page. If \( \vec{B} \) is in the plane of the page, draw it. If \( \vec{B} \) is perpendicular to the page, state whether \( \vec{B} \) points into the page or out of the page.

\[ \vec{A} \times \vec{B} \quad \vec{A} \quad \vec{B} \quad \vec{A} \times \vec{B} \quad \vec{B} \]

33. Draw the angular velocity vector on each of the rotating wheels.

a. 

b. 

c.

34. The figures below show a force acting on a particle. For each, draw the torque vector for the torque about the origin.
- Place the tail of the torque vector at the origin.
- Draw the vector large and straight (use a ruler!) so that its direction is clear. Use dotted lines from the tip of the vector to the axes to show the plane in which the vector lies.

a. 

b. 

c.
35. The figures below show a particle with velocity $\vec{v}$. For each, draw the angular momentum vector $\vec{L}$ for the angular momentum relative to the origin. Place the tail of the angular momentum vector at the origin.

![Figure a](image1.png)  
![Figure b](image2.png)  
![Figure c](image3.png)

36. Rank in order, from largest to smallest, the angular momenta $L_1$ to $L_4$.

![Diagram](image4.png)

Order:  
Explain:

37. Disks 1 and 2 have equal mass. Is the angular momentum of disk 2 larger than, smaller than, or equal to the angular momentum of disk 1? Explain.

![Diagram](image5.png)

$\omega_2 = \frac{1}{2} \omega_1$
Newton’s Theory of Gravity

1 A Little History

2 Isaac Newton

3 Newton’s Law of Gravity

1. Is the earth’s gravitational force on the moon larger than, smaller than, or equal to the moon’s gravitational force on the earth? Explain.

2. Star A is twice as massive as star B. They attract each other. 
   a. Draw gravitational force vectors on both stars. The length of each vector should be proportional to the size of the force.
   b. Is the acceleration of star A larger than, smaller than, or equal to the acceleration of star B? Explain.

3. The gravitational force of a star on orbiting planet 1 is \( F_1 \). Planet 2, which is twice as massive as planet 1 and orbits at half the distance from the star, experiences gravitational force \( F_2 \). What is the ratio \( F_2/F_1 \)?
4. Comets orbit the sun in highly elliptical orbits. A new comet is sighted at time $t_1$.
   a. Later, at time $t_2$, the comet’s acceleration $a_2$ is twice as large as the acceleration $a_1$ it had at $t_1$. What is the ratio $r_2/r_1$ of the comet’s distance from the sun at $t_2$ to its distance at $t_1$?

b. Still later, at time $t_3$, the comet has rounded the sun and is headed back out to the farthest reaches of the solar system. The size of the force $F_3$ on the comet at $t_3$ is the same as the size of force $F_2$ at $t_2$, but the comet’s distance from the sun $r_3$ is only 90% of distance $r_2$. Astronomers recognize that the comet has lost mass. Part of it was “boiled away” by the heat of the sun during the time of closest approach, thus forming the comet’s tail. What percent of its initial mass did the comet lose?

4 Little $g$ and Big $G$

5. How far away from the earth does an orbiting spacecraft have to be in order for the astronauts inside to be weightless?

6. The free-fall acceleration at the surface of planet 1 is $20 \text{ m/s}^2$. The radius and the mass of planet 2 are half those of planet 1. What is $g$ on planet 2?
Newton’s Theory of Gravity

5 Gravitational Potential Energy

7. Explain why the gravitational potential energy of two masses is negative. Note that saying “because that’s what the formula gives” is not an explanation. An explanation makes use of the basic ideas of force and potential energy.

6 Satellite Orbits and Energies

8. Planet X orbits the star Alpha with a “year” that is 200 earth days long. Planet Y circles Alpha at nine times the distance of planet X. How long is a year on planet Y?

9. The mass of Jupiter is \( M_{Jupiter} = 300M_{earth} \). Jupiter orbits around the sun with \( T_{Jupiter} = 11.9 \) years in an orbit with \( r_{Jupiter} = 5.2r_{earth} \). Suppose the earth could be moved to the distance of Jupiter and placed in a circular orbit around the sun. The new period of the earth’s orbit would be

a. 1 year.  
b. 11.9 years.  
c. Between 1 year and 11.9 years.  
d. More than 11.9 years.  
e. It could be anything, depending on the speed the earth is given.  
f. It is impossible for a planet of earth’s mass to orbit at the distance of Jupiter.

Circle the letter of the true statement. Then explain your choice.