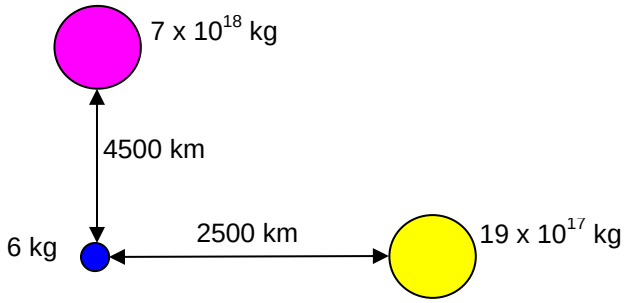
Circular Motion & Universal Gravitation
Review Sheet

Summary of Topics:

- Objects traveling in circular motion must experience a net centripetal acceleration toward the center of motion.
- Centripetal acceleration $a_c = v^2/r$
- Centripetal force $F_c = mv^2/r$
- See all of the relationships on the Translational / Rotational Summary sheet on the internet.
- Rotational Kinematics.
- Rotational Dynamics $(\Sigma\tau = I\alpha)$
- Problems incorporation translation and rotation (Atwood-like problems, rolling objects)
- Conservation of angular momentum
- Conservation of energy with rotational kinetic energy
- Universal gravitation: $F_g = \mathrm{G}\frac{m_1 m_2}{r^2}$
- Determining the acceleration of gravity on the surface of a planet.
- Satellite motion (determining orbital speeds, heights, and periods).

1. What is the resultant force on the 6-kg mass shown at right? [1.84×10^{-4} N, 48.5^o above horizontal to the right]



5. A planet of 3.7×10^{28} kg has a radius of 8.2×10^7 m. What is the acceleration of gravity on its surface. [367 m/sec^2]

6. A 760 N man drools as a 1600-kg Ferrari cruises past him. At closest approach, man and car are separated by only 4.0 meters. What was the force of attraction between them at that moment? [5.17×10^{-7} N]

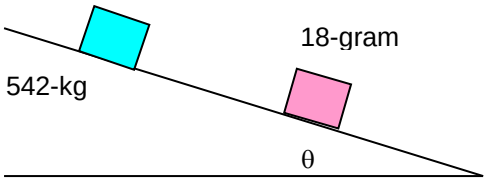
8. Upon completion of a new, super-large space telescope, a planetary system is observed on another star. The innermost planet is seen to have a period of 115 days and orbits at a distance of 8×10^9 m. What is the mass of the star? [3.07×10^{27} kg]

9. If a satellite circles the Earth in 2 hours, what is the altitude of the satellite's orbit (how high is it above the Earth)? The mass of the Earth is 5.98×10^{24} kg, the radius of the Earth is 6.38×10^6 meters. [1.68×10^6 m]

10. An astronaut, standing on a new planet, finds that a 35-kg dog weighs 1400 N. She further notes that the period of a satellite just skimming the surface of the planet (having an orbit equal to the radius of the planet) is 150 minutes. What is the radius of the planet? [8.21×10^7 m]

11. Two masses are on a frictional, horizontal surface. If the 8-kg mass is brought close to a 4.3-kg mass on a surface with a coefficient of friction of .2, at what distance will the 4.3-kg mass begin to slide toward the 8-kg mass? [1.65×10^{-5} m]

12. At what angle will the attraction of the fixed mass (the 542-kg mass) just keep the 18-gram mass from sliding down the incline? The surface is frictionless and the masses are originally separated by 13 cm. [1.25×10^{-5} degrees]



13. A 130 lb ball is swung in a horizontal circle with a steel cable. If the cable is 13.1 feet long, and it takes the ball 2.3 seconds to make one revolution, what is the force in the cable? [394.7 lb]

14. A 0.8 kg rock is spun in a circle on a 1.3 meter string. If the string breaks at 12 N tension, how fast must the rock be moving? (Neglect the effects of gravity). [4.42 m/sec]

15. A 1.3-gram cockroach stands on the edge of a 12-inch diameter record. If the record turns at 78 rev/min, what coefficient of friction is needed by the roach to keep it from slipping off? [1.04]

16. A car travels around a corner having a radius of 438 feet. If the coefficient of friction between the road and the car's tires is .3, what is the maximum speed with which the car can travel around the corner without sliding off? [44.4 miles/hour]

17. At what angle must a road be banked if a 2400 lb car traveling at 76 ft/sec is to safely negotiate a 285-ft radius curve? [32.2 degrees]

18. A boy swings a rock on a 1.4 meter string in a horizontal circle. If he swings it so that the string makes a 25^{o} angle with the horizontal, how fast must it be moving? (Hint: the radius of the rock's orbit is NOT 1.4 meters). [5.16 m/sec]

19. A car speeds over a hill at 18 m/sec. If the hill has a radius of 130 meters, what is the apparent weight of a 70-kg passenger at the top of the hill? [511.5 N]

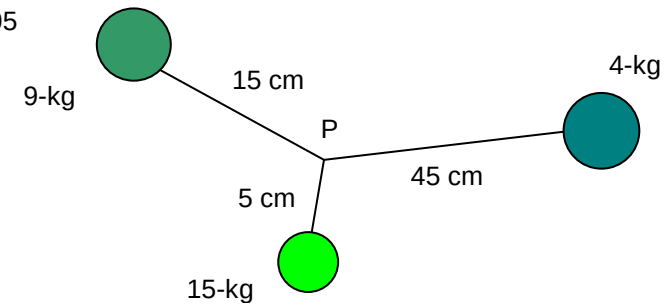
20. If a 750-gram mass is twirled in a vertical circle with a 0.82 meter string, what is the tension in the string at the top and the bottom of the orbit? Assume the mass's velocity at both top and bottom is 3.7 m/sec. [Top: 5.17 N; bottom: 19.9 N]

21. If a stunt rider wishes to do a loop-the-loop on his Harley-Davidson, what minimum speed must he attain to complete the feet? Rider and bike have a mass of 35 slugs. The diameter of the loop is 12 feet. [13.9 ft/sec]

22. What are the apparent weights of a 85-kg passenger at the top and the bottom of a 5-meter radius Ferris Wheel turning at 2.3 RPM? [Top: 808.4 N; bottom: 857.6 N]

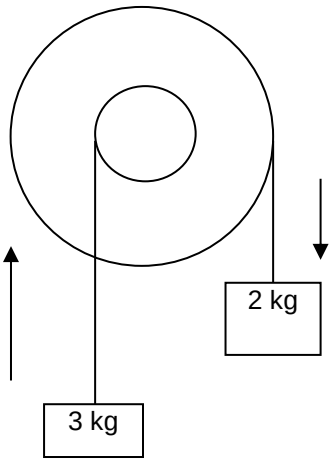
23. A 35-cm radius disk initially rotating about its center at 4 rad/sec accelerates with an angular acceleration of 6 rad/sec^2 for 13 seconds. How many revolutions does the disk make during the 13.0 seconds? What are the linear accelerations of a point at the edge of the disk 5.0 seconds after it starts accelerating in both the radial and tangential directions? [88.97 revolutions; $a_r = 404.6\ m/sec^2$; $a_t = 2.1\ m/sec^2$]

24. Calculate the moment of inertia of the system shown at right. Assume the system rotates about point P. [1.05 $kg \cdot m^2$]



25. A 1.2 kg hoop, spinning in a pool of water, gradually slows to a stop. If its acceleration is –0.4 rad/sec^2 and its radius is 0.3 m, what torque is the water applying to the hoop? [-.043 N-m]

26. A two-disk Atwood machine with radii of 15-cm and 38-cm, has a moment of inertia of 4 kg·m^2. What is the acceleration of the mass on the right? [.265 m/sec^2]



27. A 4.7-lb object with a 3.1-inch radius rolls down a 34^o slope at 14 ft/sec^2. What is its moment of inertia? [.0028 slug·ft^2]

28. What is the kinetic energy of a 3 kg disk of 0.2 m radius rolling on its rim at 4 m/sec? [36.0 J]

29. A bicycle has a 5.8 kg frame and two wheels, each at 1.3 kg. What is its total kinetic energy when it's rolling at 6 m/sec? [198 J]

30. A 470-gram sphere ($I = 2/5\ mr^2$) of 5.2 cm radius initially rolls at 8.81 m/sec. If the sphere rolls up an incline that is 2 meters high and then continues to roll on an upper horizontal surface, what will the sphere's velocity be on the upper horizontal surface? [7.04 m/sec]

31. If a spring (k = 340 N/cm) is compressed 9 cm by a disk on its side, what will the velocity of the rolling disk be when the spring is released? The disk has a mass of 1.9 kg and a radius of .3 meters. [9.83 m/sec]

32. A hula-hoop of 0.2 kg mass and 0.4 m radius spins in space at 5 rad/sec. How fast will it be spinning if it starts to get very cold and the radius shrinks to 0.3 m? [8.89 rad/sec]

33. An ice skater, spinning at 5 rad/sec has a moment of inertia of 16 kg·m^2. After pulling her arms in her moment of I is 10 kg·m^2. What is her new angular velocity? [8.0 rad/sec]

34. A 2-kg toad sits on the edge of a 3-kg lazy susan (a disk), which has a radius of 0.34 m. If the system rotates initially at 4 rad/sec and the toad hops to a point 0.10 m from the center, what is the new angular velocity? [8.37 rad/sec]