1. A toy mouse of mass 2.50 grams is placed on a turntable that rotates 45.0 rpm. The mouse is 12.0 cm from the center of the turntable. (a) Find the frequency and period of the motion. (b) Determine the speed of the mouse. (c) Find the velocity of the mouse at the northern most point in the circle. (d) Find the mouse's acceleration at the same point. (e) Find the net force.

2. (a) Suppose the frequency in the previous problem is doubled – what would be the effect on all the values? (b) Suppose the radius is doubled but frequency is still 45 rpm – what is the effect?

3. A hovercraft is set into motion in a circular path. Based on its mass, the radius, and the net force, find its speed and period.

4. A ball is placed inside a hollow plastic hemisphere (like a bowl) of radius R. The ball is set into motion and revolves in a horizontal circle around the inside of the hemisphere such that the normal is tilted by angle θ from vertical. Derive an expression for the period.

5. A man stands on the equator. Given the radius of the Earth and the radius of its orbit determine: (a) the speed of the man relative to the Earth's axis, (b) the speed of the Earth's axis relative to the Sun, (c) the speed of the man relative to the Sun at noon and at midnight on a solstice. (d) Find the acceleration of the man for each of the above.

6. A small wooden block is placed on a turntable rotating with frequency f. Derive an expression for the greatest distance from the center of the turntable at which the block can rest without sliding off.

7. A Mini Cooper of mass 1270 kg (including driver) is tested on a 300.0 ft dia. skid pad. Its best times are 14.37 s, 15.00 s, and 14.56 s. (a) Find the average best speed on the skid pad. (b) Find the best acceleration as a number of g's. (c) Find the amount of lateral friction. (d) Estimate the static coefficient of friction – what assumptions must be made?

8. Determine the ideal amount of banking for an interstate cloverleaf in terms of v and r assuming no friction "assists" in the turning of the car.

9. Determine the maximum speed a car can drive without slipping around a banked curve. Reasonable values for typical roadway and car: radius = 240 m, bank = 10.0°, coefficient static friction = 0.90.

10. Derive an expression for the centrifugal force associated with the rotation of the Earth in terms of object mass m latitude ϕ, and Earth's period T, and radius R. Use the result to determine how much a plumb bob is deflected by Earth's rotation.

11. A centrifuge rotates at 3200 rpm and the bottom end of each test tube is 9.0 cm away from the axis of rotation. (a) Determine the centrifugal force in g's. (b) If 1.00 gram of material is in the bottom of the tube what is the actual force acting upon it?

12. Use parametric equations to determine a formula and direction for the "jerk" (rate of change in acceleration) associated with uniform circular motion.

13. A point on the edge of a rolling wheel has position (in m) as functions of time (in s):
$x = 0.97t + 0.236\cos(-4.11t + 1.57)$
$y = 0.236 + 0.236\sin(-4.11t + 1.57)$
Find the acceleration and velocity of the point at time $t = 0.382$ s. Determine the rate of change in the speed at the same point. Repeat but use relative motion instead of parametric equations.

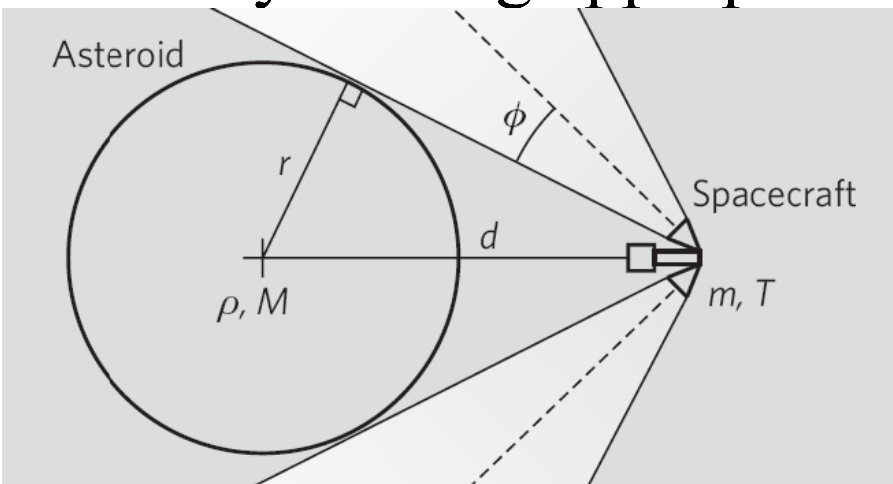
14. A car moves CCW in a circular path with radius 75 m. At the eastern most point of the circle the car has a speed 10.0 m/s but the driver steps on the accelerator, increasing the speed uniformly at 0.75 m/s per second. Determine the time for the car to reach the northern most point of the circle and determine its velocity and acceleration at that point.

15. A car initially moving west at 5.00 m/s makes a U-turn in precisely 3.00 s at which point the velocity is 3.00 m/s east. Assume the car's speed decreases uniformly. Find the magnitude of the car's acceleration 1.50 seconds into the turn.

16. (a) Determine the force of gravity that a 5.00 kg bowling ball exerts on a 200.0 g mass that is 30.0 cm from its center. (b) What happens to the magnitude of this force if the distance separating the two objects doubles? triples? halves? (c) At what distance would this force be halved? doubled? tripled?

17. "Weigh" the Earth! Measure the force of gravity on an object with known mass. Use the radius of the Earth to solve for its mass.

18. Proposals have been made to use gravity in order to tug an asteroid "out of its orbit" to avoid a collision with Earth. Inspect the figures shown below. Confirm the values shown by making appropriate calculations.



Gravity Tractor Performance Apophis	Gravity Tractor Performance 2004VD17
M = 4.6×10^{10} Kg	M = 2.6×10^{11} Kg
m = 1×10^{3} Kg	m = 1×10^{3} Kg
d = 1.5 r = 240 meters	d = 1.5 r = 435 meters
Ø = 20 degrees	Ø = 20 degrees
T = 0.053 Newtons	T = 0.092 Newtons
$\triangle V = 3.7 \times 10^{-5}$ m/sec/year	$\triangle V = 1.1 \times 10^{-5}$ m/sec/year
$\triangle V_{req} = 2 \times 10^{-6}$ m/sec	$\triangle V_{req} = 5 \times 10^{-6}$ m/sec
Deflection T_{req} = 20 days	Deflection T_{req} = 163 days
$Fuel_{req}$ = ~10 kg	$Fuel_{req}$ = 83.9 kg

19. (a) At what altitude above the surface of the Earth would you weigh less by 4.45 N supposing you weigh 800.0 N at zero elevation? (b) At what altitude would you weigh one fourth as much?

20. Find the value of g at the altitudes from the previous problem.

21. Find g at the surface of a neutron star with diameter 20.0 km and mass 1.4 times that of the Sun. What mass would have the same weight as a typical person – 750 N?

22. One method of landing a space probe on Mars is to drop it onto the surface of the planet. The probe is surrounded by air bags to protect it. Suppose the the 400.0 kg probe is dropped from a height of 20.0 m. (a) Find the impact speed. (b) Find the minimum diameter of the air bags if the deceleration is not to exceed 10 × earth *g*'s.

23. Find the strength of the gravitational field at the surface of the following in terms of Earth's surface gravity: (a) Planet *A*: half Earth's mass, same diameter as Earth, (b) Planet *B*: half Earth's mass, two third's Earth's diameter. (c) Planet *C*: same density as Earth, twice Earth's diameter. (d) Planet *D*: four times Earth's mass, three times Earth's diameter. (e) Planet *E*: one fifth Earth's density, ten times Earth's diameter.

24. Derive an expression for calculating the change in g across a certain change in elevation, h, in regions near the surface of Earth. (Hint: use a derivative to approximate this discrete change.) Use the expression to determine the variation in g from the floor to ceiling – a distance of 3.0 m. How about the variation across the 400.0 m height of a skyscraper?

25. Use the previous result to analyze tidal force in the vicinity of a black hole of mass 7.24×10^{36} kg. Determine the distance from the black hole at which the difference in g would be 9.8 m/s^2 across a person of height 1.8 m.

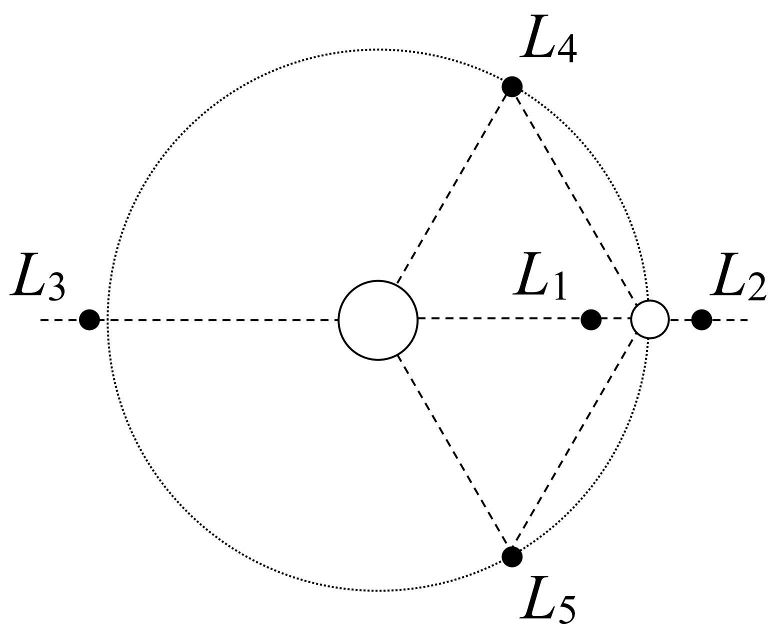
26. The Hubble Space Telescope orbits the Earth at an altitude of 540 km. Determine its speed and period.

27. The International Space Station has a circular orbit about the Earth that has a period of 91.5 minutes. Determine its speed, orbital radius, altitude and acceleration.

28. Derive an expression that gives the speed of a satellite in terms of its orbital radius.

29. Determine the mass of the Sun by analyzing the orbit of one of the planets.

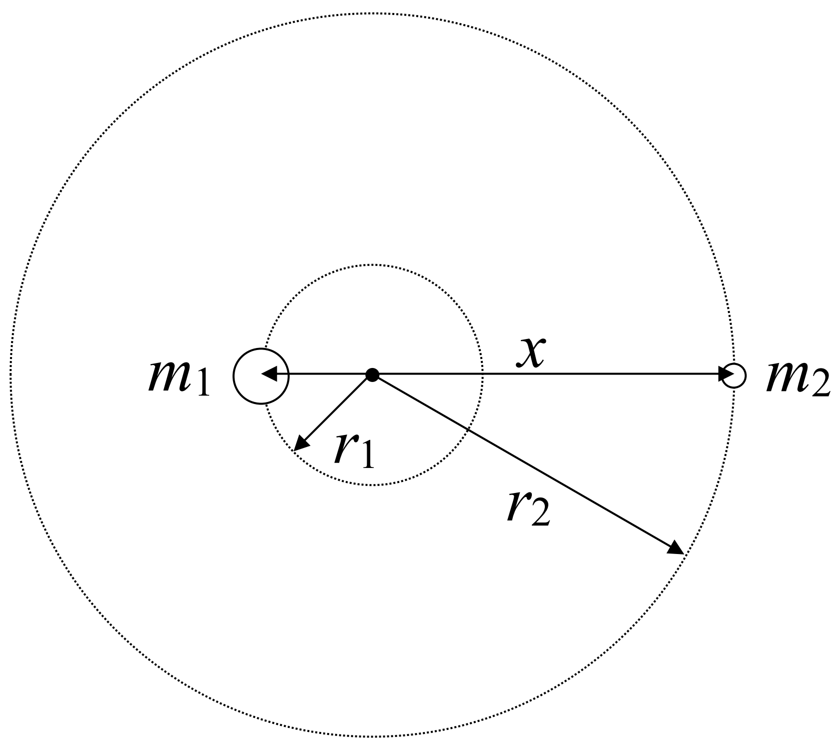
30. There are five positions at which a small object can orbit the Sun in synch with the Earth. These are called LaGrange the point. Three of these points lie on a line passing through Sun and Earth. The spacecraft SOHO is located near L_1. Determine the location of L_1.



31. Consider a moon orbiting a planet. The planet moves in a small circle opposite the moon – *i.e.* the planet "wobbles".

(a) Show that: $\frac{m_1}{m_2} = \frac{r_2}{r_1} = \frac{v_2}{v_1} = \frac{a_2}{a_1}$

(b) Derive an expression for the period of the system in terms of m_1, m_2, and x.



32. Solve for the period and each radius for the Earth and Moon based on the mass of each body and the separation:
$m_1 = 5.972 \times 10^{24}$ kg, $m_2 = 7.35 \times 10^{22}$ kg, $x = 3.84 \times 10^8$ m.