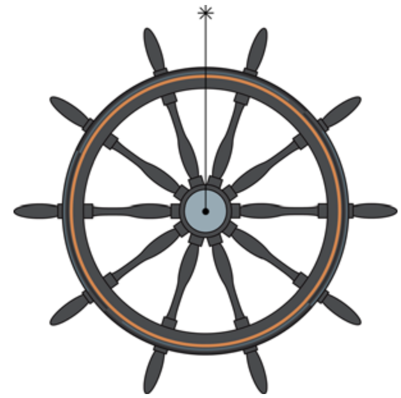
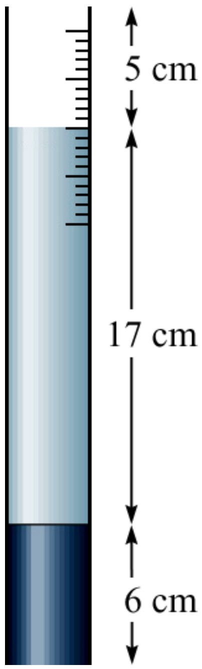
Physics 135-1 Sample Final Questions

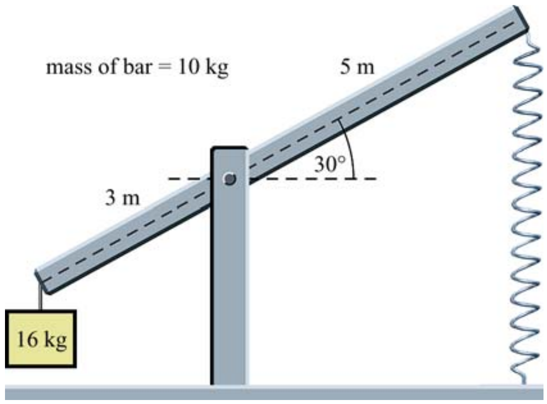


1) (10 points) You are in a maritime museum. An old ship's wheel, hanging by its center axis from a cord 1.8 meters long, is swaying very gently in the breeze. You count 17 oscillations in one minute. A sign below the wheel says it has a mass of 20 kg. What is the moment of inertia of the ship's wheel around its center axis?

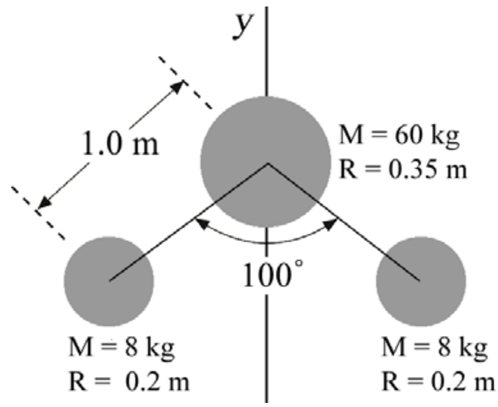


2) (10 points) You have a Physicsland® test tube whose walls have no thickness and no mass. Its radius is 1.2 cm. The test tube contains 6 cm of a tar-like sludge with a density $\rho = 1.4\ g/cm^3$. Above that it contains 17 cm of a light oil with a density $\rho = 0.9\ g/cm^3$. The top 5 cm of the test tube are empty. If I float the test tube in water, how far below the top lip of the test tube will the waterline be?

3) (10 points) A uniform bar that is 8 meters long, with a mass of 10 kg, is attached to a frictionless pivot 3 meters from one end. It is slanted at 30° from the horizontal. A mass of 16 kg is hanging from the short end at shown at right, and a vertical spring is attached to the other end. Nothing is moving. What force is the spring exerting on the bar, and is the spring compressed or stretched? (You do not need to know either the spring constant *k* or the spring's equilibrium length.)



4) (10 points) The figure shows three spheres connected by two stiff, massless rods. The large sphere has M = 60 kg and R = 0.35 m. Two identical smaller spheres have M = 8 kg and R = 0.2 m. The center-to-center length of the rods is 1 m and they are 100° apart. What is the moment of inertia of this system around the y-axis?



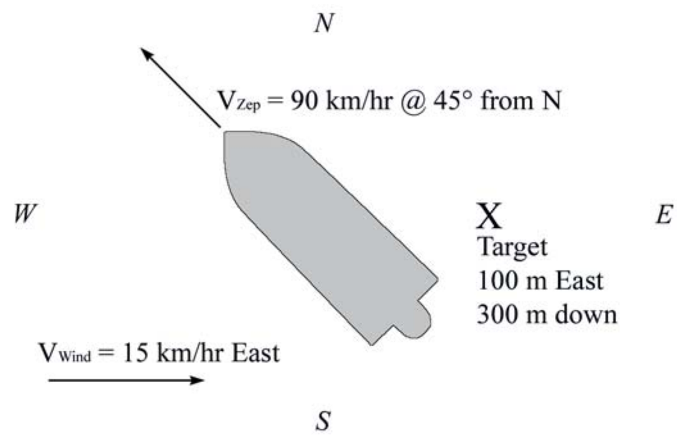
5) (10 points) For the same spheres as in Problem 5, suppose I place a point mass of 1 kg on a line directly below the large sphere at a distance of 2 m as measured from the large sphere's center, i.e., at (x, y) = (0, –2) if the coordinate origin is at the large sphere's center. What is the direction and magnitude of the gravitational force acting on the point mass, due to the three spheres?

6) (5 points) I have a rocket whose mass is 100 kg, when it is unfueled. Fully fueled, it has a mass of 160 kg. When the fuel is ignited, it will completely burn out in 10 seconds. Assume that the fuel burns at a constant rate and exits the rocket at a speed of 600 m/s. If the rocket is setting on a launch pad on Mars, what is its instantaneous acceleration (relative to the Martian surface) at the instant the fuel is ignited?

A) 3.8 m/s^2	B) 22.5 m/s^2	C) 36 m/s^2	D) zero (too massive to rise)
E) 26.4 m/s^2	F) 18.7 m/s^2	G) 60 m/s^2	H) 2.4 m/s^2

7) A Zeppelin airship is flying at a speed of 90 km/hr on a heading 45° counter-clockwise of North, relative to the surrounding air. A wind is blowing East at 15 km/hr, relative to the ground. The figure shows a “top” view of the Zeppelin.

a) (5 points) At what speed and in what direction (angle from North) is the Zeppelin moving relative to the ground? Assume that counter-clockwise is a positive angle.



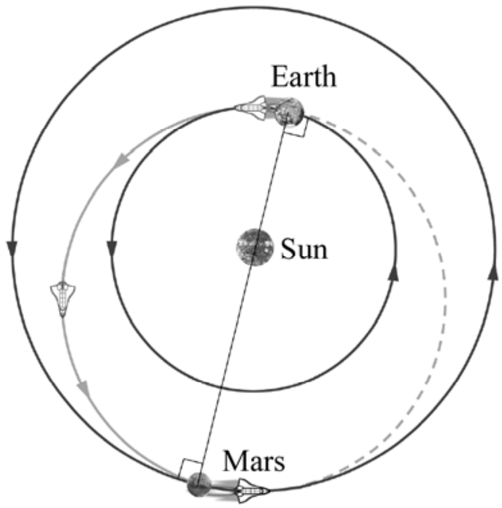
A) 80 km/hr @ +37°
B) 75 km/hr @ +45°
C) 85 km/hr @ –4°
D) 95 km/hr @ +35°
E) 101 km/hr @ +51°
F) 80 km/hr @ –53°
G) 90 km/hr @ –45°
H) 64 km/hr @ +15°

b) (5 points) The Zeppelin is 300 meters above the ground. It must drop a packet of medical supplies on a point (“X” marks the spot) that is 100 meters east of its present position. Assume that the initial velocity of the packet has no z-component (no “up” or “down” initial velocity) relative to the Zeppelin. What velocity vector in North/South and East/West components (i.e., in x- and y-components, where x is E-W and y is N-S) must the packet have relative to the Zeppelin to hit the “X” target? You may assume zero air friction.

All answers have units of m/s. Positive is East and North, respectively.

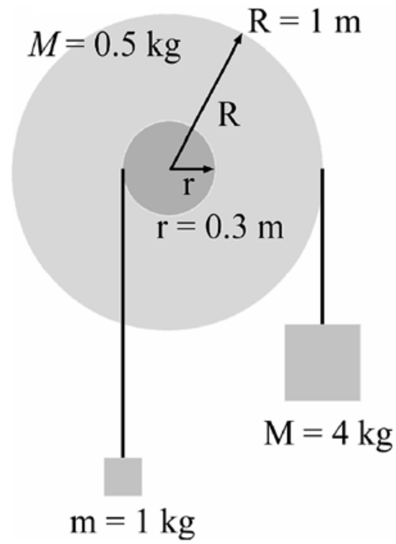
A) $\mathbf{v} = 15.0\,\mathbf{i} - 17.7\,\mathbf{j}$
B) $\mathbf{v} = 1.6\,\mathbf{i} + 17.7\,\mathbf{j}$
C) $\mathbf{v} = 26.3\,\mathbf{i} - 17.7\,\mathbf{j}$
D) $\mathbf{v} = -15.1\,\mathbf{i}$ + zero $\mathbf{j}$
E) $\mathbf{v} = 11.9\,\mathbf{i}$ + zero $\mathbf{j}$
F) $\mathbf{v} = -11.9\,\mathbf{i}$ + zero $\mathbf{j}$
G) $\mathbf{v} = -11.9\,\mathbf{i} - 63.6\,\mathbf{j}$
H) $\mathbf{v} = 26.3\,\mathbf{i} + 63.6\,\mathbf{j}$
I) $\mathbf{v} = -0.7\,\mathbf{i} - 63.6\,\mathbf{j}$
J) $\mathbf{v} = 0.7\,\mathbf{i} + 17.7\,\mathbf{j}$
K) $\mathbf{v} = 48.6\,\mathbf{i} - 17.7\,\mathbf{j}$
L) $\mathbf{v} = 35.8\,\mathbf{i} + 17.7\,\mathbf{j}$

8) (10 points) In the solar system shown schematically at right, the USS Iceskater is launched tangentially to Earth's orbit at 1.82 miles/sec relative to the Earth. The Iceskater coasts in orbit around the Sun until it intersects the orbit of Mars, also at a tangent. Earth, Mars, and the spacecraft are all rotating counter-clockwise. How fast is the Iceskater moving relative to Mars, in miles/sec, when their paths intersect?



Radius of Mars orbit = 1.52 X radius of Earth's orbit
Orbital speed of Earth = 18.51 miles/sec
Orbital speed of Mars = 14.96 miles/sec

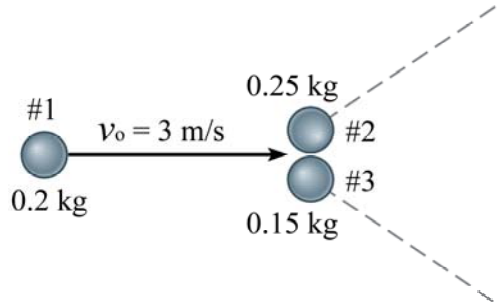
9) (15 points) A Physicsland® pulley that can rotate with no friction has two masses attached to it. The larger mass (M = 4 kg) is attached to the outside of the wheel at R = 1 m. The smaller mass (m = 1 kg) is attached to a small sleeve of negligible mass located near the center of the wheel at r = 0.3 m. Both are attached with massless cords that wrap perfectly around the wheel without slipping. The wheel can be assumed to be a perfect disk with a mass of *M* = 0.5 kg. As the larger mass falls, what is the linear acceleration of the smaller mass?



10) (10 points) An overhead view of three billiard balls on a pool table is shown at right. The masses of the balls are:

m_1 = 0.2 kg, m_2 = 0.25 kg, m_3 = 0.15 kg.

Ball #1 is moving at v_0 = 3 m/s along the x-axis; the other balls are stationary. Then ball #1 collides *perfectly elastically* between the other balls and stops. It transfers $^1/_2$ of its momentum to ball #2 and $^1/_2$ to ball #3. What are the velocity vectors of balls #2 and #3 after the collision (in **i** and **j** notation)?



11) (4 points) Titan, the largest moon of Saturn, is 80% more massive than our Moon and has a radius 48% larger than our Moon. If the surface gravity on the Moon is 1.63 m/s^2, what is the surface gravity on Titan?

A) 2.92 m/s^2 B) 1.98 m/s^2 C) 2.41 m/s^2 D) 0.74 m/s^2 E) 1.34 m/s^2 F) 1.01 m/s^2

12) (4 points) The following objects are rolling along the floor with equal linear velocities. They all have the same mass and radius, but different shapes. Which one has the most kinetic energy?

A) hoop B) long cylinder C) thin disk D) sphere E) spoked wheel F) short cylinder

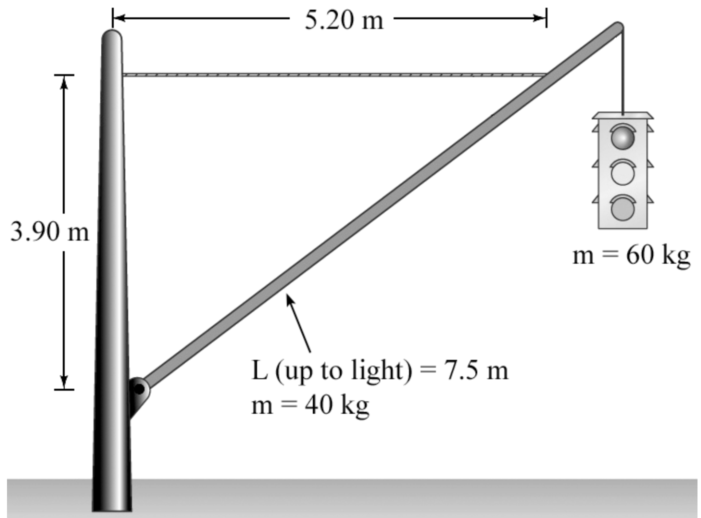
13) (3 points) If you take a spinning gyroscope and drop it off a tall building (neglect air friction), it will:

A) precess all the way down at constant ω
B) precess all the way down with ω gradually decreasing
C) not precess, but tumble randomly
D) precess all the way down with ω gradually increasing
E) not fall at all
F) neither precess nor tumble, but point in one direction

14) (3 points) What is the gravitational force between two 100 kg football players who are 0.5 m apart?

A) 2.67×10^{-6} N B) 6.67×10^{-11} N C) 6.67×10^{-7} N
D) 1.34×10^{-6} N E) 2.67×10^{-8} N F) 1.33×10^{-10} N

15) (10 points) Suppose we have a traffic light hanging from the end of a boom of mass = 40 kg, length = 7.5 m. The boom is of uniform width and density, and is free to pivot around a frictionless pin at the bottom. A 5.2 m cord is tied to the boom at a height of 3.9 m above the pivot. The traffic light is connected to the very end of the boom, and has a mass of 60 kg. What is the tension in the cord?



A) 980 N
B) 905 N
C) 678 N
D) 1045 N
E) 123 N
F) 1206 N
G) 510 N
H) 600 N
I) 723 N
J) 434 N

16) (4 points) A standard bowling ball is 21.6 cm in diameter and has a mass of 7.26 kg. If a bowler releases a bowling ball which rolls without slipping at a velocity of 13.7 m/s, how much kinetic energy does the bowling ball have?

A) 6.81 J	B) 273 J	C) 1022 J	D) 954 J	E) 545 J
F) 681 J	G) 408 J	H) 1226 J	I) 341 J	J) 1362 J

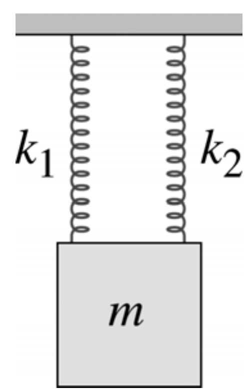
17) (5 points) Mars has two tiny moons, Deimos and Phobos (aka Panic and Fear). Deimos orbits 23,436 km from Mars with a period of 1.262 Earth days. Phobos orbits 9377 km from Mars. How long does Phobos take to make one orbit?

A) 1.98 days	B) 0.319 day	C) 0.506 day	D) 3.13 days	E) 0.685 day
F) 0.632 day	G) 0.251 day	H) 1.58 days	I) 2.32 days	J) 0.430 day

18) (4 points) The "large" Martian moon, Phobos, has a radius of about 11 km and a mass of 1.08×10^{16} kg. If you stood on the surface of Phobos, how fast would you have to throw a baseball to place it into orbit around Phobos (assuming the orbit is barely above the ground)?

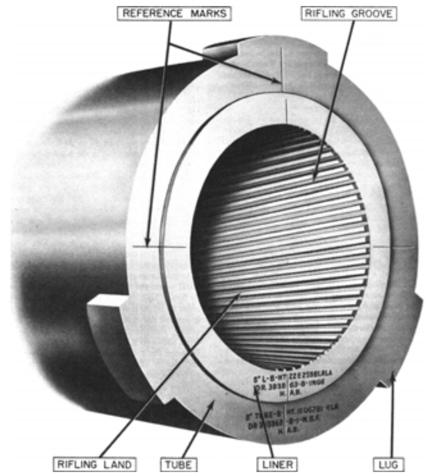
A) 8.1 m/s	B) 8.1 km/s	C) 256 m/s	D) 4.0 m/s
E) 66 m/s	F) 128 m/s	G) 16.2 m/s	H) 7.0 km/s

19) (5 points) We have a 500-gm mass and two springs with constants k_1 and k_2. If only the first spring (k_1) is connected to the mass, then its oscillation frequency is 5 Hz. If only the second spring (k_2) is connected to the mass, then its oscillation frequency is 10 Hz. What is the oscillation frequency when both springs are connected to the mass?



A) 5.4 Hz	B) 8.7 Hz	C) 11.2 Hz	D) 15 Hz
E) 7.5 Hz	F) 10.5 Hz	G) 14.4 Hz	H) 12.5 Hz

20) (4 points) Prior to the end of the eighteenth century, most firearms had smooth bores – that is, their barrels were perfectly smooth cylinders on the inside. After that time, arms makers increasingly moved to "rifled" barrels, which were barrels that had fine lines or grooves engraved on the inside in a shallow spiral (see illustration at right). The purpose of the grooves was to put a lot of spin on the bullet. The question is, why would you want to put a lot of spin on a bullet?



A) Spin makes the bullet give off a frightening whine.
B) The added rotational kinetic energy makes the bullet more destructive.
C) The angular momentum vector keeps it pointed ahead for better accuracy.
D) The centrifugal force helps the bullet maintain its shape.
E) A spinning bullet experiences less air friction.
F) All of the above
G) None of the above.