PHY2020 **Test 2** **November 5, 2014**

Name:____

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\begin{aligned}
\sin(30) &= 1/2 \\
\cos(30) &= \sqrt{3}/2 \\
\tan(30) &= \sqrt{3}/3 \\
\sin(60) &= \sqrt{3}/2 \\
\cos(60) &= 1/2 \\
\tan(60) &= \sqrt{3} \\
\sin(45) &= \cos(45) = \sqrt{2}/2 \\
\tan(45) &= 1 \\
\sin(37) &= \cos(53) = 0.6 \\
\cos(37) &= \sin(53) = 0.8 \\
\tan(37) &= 1/\tan(53) = 3/4
\end{aligned}
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$1N$	$= 1\,\mathrm{kg\,m/s^2}$	units of Force
$\vec{x}$	$= \vec{x}_0 + \vec{v}_0 t$	const speed
$\vec{v}$	$= \vec{v}_0 + \vec{a}t$	const acceleration
$\vec{x}$	$= \vec{x}_0 + \vec{v}_0 t + \frac{1}{2}\vec{a}t^2$	const acceleration
F	$= Mv^2/R$	Centripetal force pointing toward the center of circular motion
F	$= M\omega^2 R$	Centripetal force pointing toward the center of circular motion
v	$= 2\pi R/T$	T is the period of rotational motion.
a	$= v^2/R$	a is the magnitude of the centripetal acceleration.
F	$= GM_1M_2/R^2$	Newton's Law of gravity
G	$= 6.7 \times 10^{-11}\,\mathrm{N\,m^2/kg^2}$	Newton's Gravitational Constant.
g	$= 10\,\mathrm{m/s^2}$	Acceleration of gravity at the surface of the Earth
g	$= GM/R^2$	gravity at the surface of a round planet of mass M and radius R
KE	$= \frac{1}{2}mv^2$	kinetic energy
PE	$= mgh$	potential energy for gravity at the Earth's surface
PE	$= \frac{1}{2}kx^2$	potential energy of a stretched spring, with spring constant k
T	$= 2\pi\sqrt{M/k}$	Period of simple harmonic motion for a mass M and a spring constant k
W	$= F\,d$	work
$\vec{P}$	$= m\vec{v}$	momentum
v	$= \omega r$	speed of a point (at distance r from axis) on an object that is rotating
v	$= \omega R$	speed of the center of a rolling wheel of radius R.
τ	$= Fr$	torque when $\vec{F}$ and $\vec{r}$ are perpendicular to each other.
τ	$= I\alpha$	where τ is the torque, I is rotational inertia, and α is angular acceleration.
L	$= I\omega$	angular momentum of a spinning object
L	$= mvr_\perp$	angular momentum, where $r_\perp$ is the part of $\vec{r}$ that is perpendicular to $\vec{v}$
power	= Work/time	power

$I_{\mathrm{cm}} = \frac{1}{3}m\ell^2$: Rotational inertia about the center of mass of a stick of mass m and length ℓ.
$I_{\mathrm{cm}} = \frac{2}{5}mR^2$: Rotational inertia of a solid ball, about the center of mass.
$I_{\mathrm{cm}} = mR^2$: The rotational inertia of a hoop, about the center of mass.
$I_{\mathrm{cm}} = mR^2/2$: The rotational inertia of a circular disk, about an axis through the center.

The mass of an electron is 9×10^{-31} kg.
Unit of a magnetic field is 1 Tesla $= 1\,\mathrm{N}/(1\mathrm{Coulomb} \times 1\,\mathrm{m/s}) = 1\,\mathrm{kg}/(1\mathrm{C}\cdot\mathrm{s})$

$$
\begin{aligned}
1\mathrm{C} &= 6 \times 10^{18} \text{ protons} \\
-1\mathrm{C} &= 6 \times 10^{18} \text{ electrons} \\
1\mathrm{e}^- &= -1.6 \times 10^{-19}\mathrm{C} \\
V &= IR \qquad \text{Ohm's law} \\
P &= IV \qquad \text{Power loss} \\
F &= kq_1q_2/r^2 \qquad \text{Coulomb's law} \\
k &= 9 \times 10^9\,\mathrm{N\,m^2/\,C^2} \\
F &= qE, \text{ Force on a charge in an electric field.} \\
F &= qvB \text{ when } \vec{v} \perp \vec{B} : \text{for a charge moving in a circle in a magnetic field, the force points inward.} \\
F &= 0 \text{ when } \vec{v} \parallel \vec{B} : \text{for a charge moving in a magnetic field.}
\end{aligned}
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$v_s = 340\,\mathrm{m/s}$ speed of sound in air
$\lambda f = v_{sound}$, $\lambda =$ wavelength, $f =$ frequency in Hz, $\omega = 2\pi f$ angular frequency in radians/s
$f_{heard} = \frac{v_{sound} f_{emitted}}{v_{sound} - v_{plane}}$ Doppler effect for an airplane approaching
$f_{heard} = \frac{v_{sound} f_{emitted}}{v_{sound} + v_{plane}}$ Doppler effect for an airplane moving away
For an organ pipe of length L and with one end open: $\lambda_n = 4L/(1 + 2n)$, where n is an integer.
The "fundamental" mode has n = 0.

Simple Harmonic Motion: (also known as a mass on a spring, or a simple pendulum)

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\begin{aligned}
F &= -kx, && \text{where } k = \text{spring constant} \\
T &= 2\pi\sqrt{m/k} && = \text{ period} \\
T &= 2\pi\sqrt{\ell/g} && = \text{ period, where } \ell \text{ is the length of a pendulum} \\
x(t) &= A\cos(2\pi f t), && \text{where } A = \text{Amplitude, } 1/T = f = \text{frequency in Hz, } t = \text{time,} \\
& && x(t) = \text{displacement as a function of } t
\end{aligned}
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1. (1 pt) In a demonstration, you saw a heavy ball hanging from a thin string above with a second thin string dangling below. When I jerked the bottom string: (Circle the correct response.)

   (a) Only the top string broke.

   (b) Only the bottom string broke.

   (c) Both strings broke.

   (d) Neither string broke.

   (e) The ball landed on my foot.

2. (1 pt) And this was because the ball was so massive and (Circle the correct response.)

   (a) Newton's second law, F=ma.

   (b) Galileo's principle of superposition.

   (c) The conservation of energy.

   (d) The string was weak.

   (e) Both strings were weak.

3. (1 pt) When I slowly pulled on the bottom string (Circle the correct response.)

   (a) Only the top string broke.

   (b) Only the bottom string broke.

   (c) Both strings broke.

   (d) Neither string broke.

   (e) The ball landed on my foot.

4. (4 pts) Your mass is $m = 50\,\text{kg}$ and you are riding on a roller coaster where you are completely upside-down at the top of a circular loop whose radius is $7\,\text{m}$. Being a physics student, you brought along a bathroom scale to sit on, and you note that when you are precisely upside down (so that the scale is actually above you) the scale reads $0\,\text{N}$.

   (a) At that moment when you are precisely upside-down, what is magnitude of the normal force $\vec{N}$, in Newtons, that the scale is exerting on your bottom?

   (b) At that same moment, what is your acceleration?

5. (2 pts) A two meter long see-saw is balanced on a fulcrum in the middle. A girl of mass $40\,\text{kg}$ sits at the end of the see-saw a distance $1\,\text{m}$ from the fulcrum. A boy of mass $50\,\text{kg}$ sits on the other side of the see-saw to balance the see-saw. How far is the boy from the fulcrum?

6. (4 pts) You have an inclined plane and three objects of identical mass M. Mass A is a uniform solid cylinder of radius R, Mass B is a hoop of radius R (all of the mass is distributed along the outer rim of the object), and Mass C is a cube with each edge of length R. The cylinder and the hoop will roll without slipping down the inclined plane, but the cube will just slide down the inclined plane with no friction.

   (a) In a race, which mass would be the first one down the inclined plane?

   (b) Which mass would be the second one down the inclined plane?

7. (2 pts) A spool with a pink ribbon around it is on the front desktop. If the ribbon is pulled gently to the right, and if the spool rolls without slipping, it will
   (Circle your answer.)

   (a) move to the left.
   (b) stay in the same place.
   (c) move to the right.
   (d) lift off the table.

8. (6 pts) A block of mass 1 kg is whirled around in a vertical circle on the end of a string 1 m long. Assume that the block has the minimum speed possible to complete the circle at the top.

   (a) What is the minimum speed the block might have at the top of the circle?

   (b) What is the magnitude of the acceleration of the block when it is at the top of the circle?

   (c) What is the speed of the block when it is at the bottom of the circle?

9. (2 pts) A spring is held compressed between a block M_1 of mass 1 kg and another block M_2 of mass 2 kg. The two blocks are then released simultaneously, they move in opposite directions on a frictionless surface, and M_1 is measured to have a speed of 2 m/s. What, then, is the speed of M_2?

10. (6 pts) A 4 kg mass and a 2 kg mass are attached to each other by a string which has a length of 3 m. The 4 kg mass is 1 m away from the center of mass of the system.

    (a) How far is the 2 kg mass from the center of mass of the system?

    (b) Each mass moves in a different circle about the common center of mass, and the 4 kg mass moves with a speed of 1 m/s. How fast does the 2 kg mass move about the center of mass?

    (c) What is the tension in the string?