Name:________________________________

- The number of possible points is given with each problem. Some problems have more than one question.
- Show all of your work.
- For numerical problems include units on all answers—if the units are not given or are incorrect, then you will lose 1 point.
- Use $g = 10\,\mathrm{m/s^2}$.
- Simplify all arithmetic. For example, if you were to give an answer as $\sqrt{8/2}$ instead of 2, then you will lose 1 point for the answer, just as you would if you did not give the appropriate units for the answer.

$$\begin{aligned}
\sin(30) &= 1/2 \\
\cos(30) &= \sqrt{3}/2 \\
\tan(30) &= \sqrt{3}/3 \\
\sin(60) &= \sqrt{3}/2 \\
\cos(60) &= 1/2 \\
\tan(60) &= \sqrt{3} \\
\sin(45) &= \cos(45) = \sqrt{2}/2 \\
\tan(45) &= 1 \\
\sin(37) &= \cos(53) = 0.6 \\
\cos(37) &= \sin(53) = 0.8 \\
\tan(37) &= 1/\tan(53) = 3/4
\end{aligned}$$

$\vec{x}$	$= \vec{x}_0 + \vec{v}_0 t$	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
v	$= 2\pi R/T$	T is the period of the 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	$= 10\,\mathrm{m/s^2}$	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
W	$= \vec{F}\cdot\vec{d}$	work
$\vec{P}$	$= m\vec{v}$	momentum
v	$= \omega R$	speed of a rolling wheel
τ	$= \vec{r}\times\vec{F} = I d\omega/dt$	torque
I	$= \sum_i m_i r_i^2$	rotational inertia
L	$= I\omega$	angular momentum
power	$=$ Work/time	power

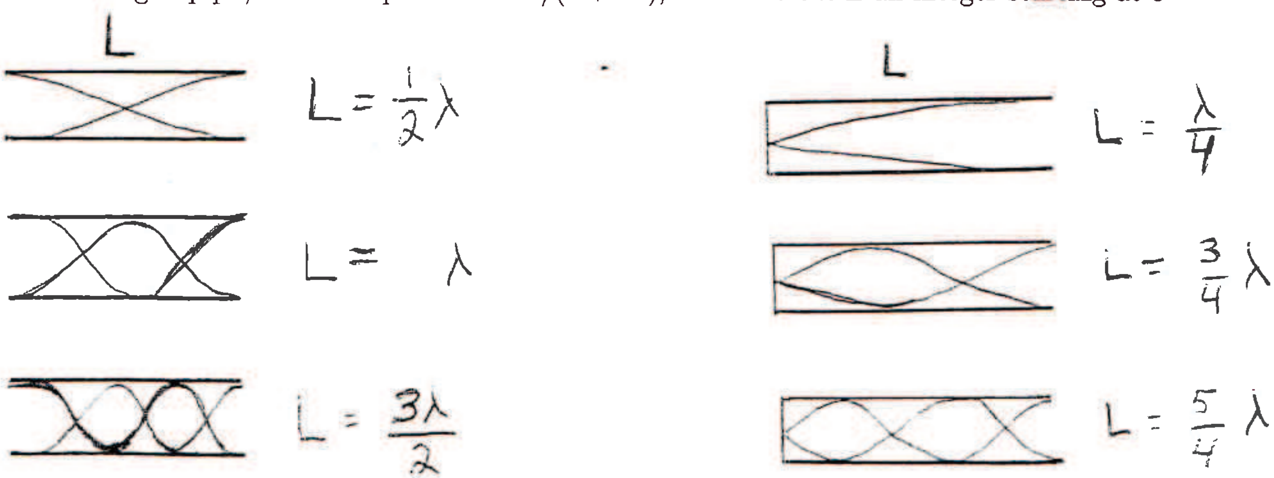
Charge: $1\text{C} = 6 \times 10^{18}$protons
Charge: $-1\text{C} = 6 \times 10^{18}$electrons
Charge of 1 electron $= -1.6 \times 10^{-19}\text{C}$
$1\text{eV} = -1.6 \times 10^{-19}\text{J}$
$F = kq_1q_2/d^2$ Coulomb's law
Here, in Coulomb's law $k = 9 \times 10^9\,\text{N}\,\text{m}^2/\,\text{C}^2$

units of Force: $1N = 1\,\text{kg}\,\text{m}/\,\text{s}^2$
units of Pressure: $\text{N}/\,\text{m}^2$, At sea level: $P = 1 \times 10^5\text{Pa}$
$1\text{Pa} = 1\,\text{N}/\,\text{m}^2$,
$P = NkT/V$ T is measured in degrees Kelvin.
That is, absolute zero is a temperature 0° K

$$P = F/A = mg/A = (\rho V)g/A = \rho gV/A = \rho gd$$

Sound:

sound in air: $\lambda f = v_{sound}$
$f_{heard} = \frac{v_{sound} f_{emitted}}{v_{sound} - v_{plane}}$ Doppler effect for an airplane approaching
organ pipe, both ends open: $\lambda = 2L/n$, where n is an integer starting at 1
organ pipe, one end open: $\lambda = 4L/(1+2n)$, where n is an integer starting at 0



Simple Harmonic Motion:

F	$= -kx$,	where $k =$ spring constant
T	$= 2\pi\sqrt{m/k}$	= period
T	$= 2\pi\sqrt{\ell/g}$	= period, where ℓ is the length of the pendulum
$x(t)$	$= A\cos(2\pi ft)$,	where $A =$ Amplitude, $f =$ frequency, $t =$ time, $x(t) =$ displacement as a function of t

For a floating object:

fraction above the fluid	$= 1 - \rho_{\text{obj}}/\rho_{\text{fluid}}$,	where ρ is density
fraction below the fluid	$= \rho_{\text{obj}}/\rho_{\text{fluid}}$	
buoyant force on obj	= weight of fluid displaced by the object	