Spring 2014 Practice Final (Brotherton)

Phys 1210 (Ch. 1-10, 12-16) _______

your name

The exam consists of 7 problems. Each problem is of equal value.

You can skip two of the problems (best five will count if you do all problems). Calculators are allowed.

<u>Tips for better exam grades:</u>

Read all problems right away and ask questions as early as possible.

Make sure that you give at least a basic relevant equation or figure for each sub-problem.

Make use of the entire exam time. When you are done with solving the problems and there is some time left, read your answers over again and search for incomplete or wrong parts.

Show your work for full credit. The answer '42' only earns you any credit IF '42' is the right answer. We reserve points for 'steps in between', figures, units, etc.

No credit given for illegible handwriting or flawed logic in an argument.

Remember to give units on final answers.

Please box final answers so we don't miss them during grading.

Please use blank paper to write answers, starting each problem on a new page.

Please use 10 m/s^2 as the acceleration due to gravity on Earth.

'Nuff said.

1. **Godzilla Smacks Hulk.**
   Hulk gets mad at the wrong force of nature, and Godzilla shows Jadejaws who is boss. When the Hulk jumps to attack Godzilla, Godzilla hits him hard and sends him flying. If the Hulk is knocked back at an upward angle of 30 degrees at a speed of 200 m/s, from an altitude of 100 meters, how far away in meters does he land from Godzilla?

2. **Batman in Trouble.**
   Okay, he's going to solve his problem, because he is "The Goddamn Batman," but…at the moment he is sliding down a slope toward a cliff edge, being pulled by a Bat Cable from which dangles Robin. Batman masses 100 kg, while Robin is a boy wonderish 50 kg. The coefficient of kinetic friction is 0.3. The slope has an angle of 45 degrees. Assume a frictionless cliff edge. What is the tension (in Newtons) in the cable?

3. **Wonder Woman Tackles Cheetah.**
   Wonder Woman spots Cheetah running from a jewel heist, launching herself and tackling her in mid stride, wrapping her up and taking her down in a bear hug. If Wonder Woman has a mass of 80 kg and runs at 10 m/s, Cheetah has a mass of 60 kg and runs at 8 m/s, how fast is the pair moving just after Wonder Woman's tackle? What is the ratio of final to initial kinetic energies of the pair?

4. **Quicksilver hits Spider-man…a lot. Angles and impulse**
   The cover of The Amazing Spider-Man issue #71 shows Quicksliver attacking our hero, running in a circle around him and punching him repeatedly, five times each circle. Ouch! If Quicksilver starts from rest one meter away from Spider-man, and accelerates with a constant linear (tangential) acceleration of 10 m/s^2 for 10 seconds, moving in a circle, what is his final linear (tangential) speed in m/s? His final kinetic energy (assuming a mass of 70 kg) in Joules? His final angular speed around Spider-man in radians per second? How many times does he hit poor Spider-man?

5. **Geosynchronous JLA Watchtower.**
   The Justice League of America's headquarters is a satellite in space in geosychronous orbit. That is, its orbital period is equal to 1 day, such that it remains fixed over a particular location on the Earth's surface. What is the Watchtower's distance from the center of the Earth in meters? Assume the mass of the Earth is 5.97×10^{24} kg.

6. **Stiltman Walks!**
   Stilt-man was one of Daredevil's earliest villains, having a special suit with telescopic legs that could grow to a length of 75 meters, letting him pull off high-altitude heists. What would be Stilt-man's natural walking speed? Assume his legs are fully extended, have a mass of 100 kg each, that they can be treated as a uniform rod pivoted at their

top, and that they can be modeled as a physical pendulum. Assume a stride length of 25 meters.

7. **Black Canary's Cry.**
While the Black Canary prefers hand-to-hand combat, she possesses a powerful "Canary Cry" capable of rendering her opponents helpless and destroying obstacles. Assuming a sound speed of 344 m/s in air, what is the wavelength of her ultrasonic cry at 50,000 Hz? If the intensity of her cry is 150 dB experienced by a foe at 10 meters, what is the intensity in decibels for a foe at 20 meters?

Master Equations – Physics 1210

One-dimensional motion with constant acceleration:

① $x = x_0 + v_{0x}t + \frac{1}{2}a_x t^2$ find the other forms of master equation 1 by

(a) building the derivative of the equation
(b) solving the new equation for t and substituting it back into the master equation, and
(c) using the equation for average velocity times time

Two-dimensional motion for an object with initial velocity v_o at an angle α relative to the horizontal, with constant acceleration in the y direction:

② $x = x_0 + v_0 cos\alpha\, t$

③ $y = y_0 + v_0 sin\alpha\, t + \frac{1}{2}a_y t^2$ find the related velocities by building the derivatives of the equations

Newton's Laws

④ $\Sigma\vec{F} = 0,\ \Sigma\vec{F} = m\,\vec{a},\ \vec{F}_{A\to B} = -\vec{F}_{B\to A}$ find the related component equations by replacing all relevant properties by their component values

The quadratic equation and its solution:

$$a \cdot x^2 + b \cdot x + c = 0\ , then\ x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

Table with some values for trig functions:

Degrees:	30	45	60	330	
sin	0.5	0.707	0.866	-0.5	
cos	0.866	0.707	0.5	0.866	
tan	0.577	1	1.732	-0.577	

Work and Power definitions:

Work $\boldsymbol{W = \vec{F} \cdot \vec{s} = Fs\cos\phi}$
Power P = dW/dt

Hook's Law:

F = kx (where k is the spring constant)

Kinetic Energy:

$K = \frac{1}{2} mv^2$ (linear)
$K = \frac{1}{2} I \omega^2$ (rotational)

Potential Energy:

U = mgh (gravitational)
$U = \frac{1}{2} kx^2$ (elastic for a spring constant k)

Work-energy with both kinetic and potential energy:

$K_1 + U_1 + W_{other} = K_2 + U_2$

Linear Momentum:

$\boldsymbol{\vec{p} = m\vec{v}\ and\ \vec{F} = d\vec{p}/dt}$

Impulse and Impulse-Momentum Theorem:

$\boldsymbol{\vec{J} = \int_{t1}^{t2} \sum \vec{F}\ dt = \vec{p}_2 - \vec{p}_1}$

Angular-Linear Relationships:

$a = v^2/r$ (uniform circular motion)
$v = r\omega$, $a_{tan} = r\alpha$, and $a_{rad} = v^2/r = r\omega^2$

Parallel axis theorem for the moment of inertia I:

$I_p = I_{cm} + Md^2$

Angular dynamics:

Torque $\boldsymbol{\vec{\tau} = \vec{r}\ X\ \vec{F}}$ **and** $\boldsymbol{\sum \tau_z = I\alpha_z}$

Angular Momentum:

$$\vec{L} = \vec{r}\, X\, \vec{p} \;\; and\, \vec{\tau} = d\vec{L}/dt$$

Fluid Mechanics

$p = p_0 + \rho gh$ (pressure in an incompressible fluid of constant density)
$A_1V_1 = A_2V_2$ (continuity equation, incompressible fluid)
$dV/dt = Av$
$p_1 + \rho gy_1 + ½ \rho v_1^2 = p_2 + \rho gy_2 + ½ \rho v_2^2$ (steady flow, ideal fluid)

Gravity:

$F = Gm_1m_2/r^2$
$U = -Gm_Em/r$
T (orbital period) = $2 \pi r^{3/2}/\text{sqrt}(Gm_E)$
$G = 6.67x10^{-11}$ N·(m/kg)^2

Periodic Motion

f = 1/T; T= 1/f
ω = 2π f = 2π/T (angular frequency here)
ω = sqrt(k/m) (k is spring constant)
x = A cos(ωt + Φ)
ω = sqrt (κ/I) (angular harmonic motion)
ω = sqrt (g/L) (simple pendulum)
ω= sqrt (mgd/I) (physical pendulum)

Mechanical Waves in General

V = λf
Y(x,t) = A cos (kx- ωt) (k is wavenumber, k = 2 πf)
V = sqrt (F/μ)
$P_{av} = ½ \text{sqrt}(\mu F)\, \omega^2 A^2$
$I_1/I_2 = (r_2/r_1)^2$ (inverse square law for intensity)

Sound Waves

P_{max} = BkA (B is bulk modulus)
B = (10 dB) log(I/I_0) where $I_0 = 1x10^{-12}$ W/m^2
$f_L = f_s * (v+v_L)/(v+v_s)$ -- Doppler effect

Table 9.1 Comparison of Linear and Angular Motion with Constant Acceleration

Straight-Line Motion with Constant Linear Acceleration	Fixed-Axis Rotation with Constant Angular Acceleration
$a_x = \text{constant}$	$\alpha_z = \text{constant}$
$v_x = v_{0x} + a_x t$	$\omega_z = \omega_{0z} + \alpha_z t$
$x = x_0 + v_{0x}t + \frac{1}{2}a_x t^2$	$\theta = \theta_0 + \omega_{0z}t + \frac{1}{2}\alpha_z t^2$
$v_x^2 = v_{0x}^2 + 2a_x(x - x_0)$	$\omega_z^2 = \omega_{0z}^2 + 2\alpha_z(\theta - \theta_0)$
$x - x_0 = \frac{1}{2}(v_x + v_{0x})t$	$\theta - \theta_0 = \frac{1}{2}(\omega_z + \omega_{0z})t$