Practice Exam 2 (Brotherton)

Phys 1210 (Ch. 6-10) ________

your name

The exam consists of 6 problems. Each problem is of equal value.

You can skip one of 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. **Superman turns an asteroid.**
   A deadly asteroid is hurtling toward Earth with a velocity of 20.0 km/s. Superman intercepts it, applies a force over a time, so that its new trajectory has changed by 30 degrees, and its speed is now 18.0 km/s. If the mass of the asteroid is 10,000 kg, how much work has Superman done?

2. **Hulk Throws a Tantrum (and a Tank)**
   Let's revisit a problem from the last exam, this time using energy conservation to solve the problem. The incredible Hulk is still mad. Very mad. The army is chasing him around New Mexico again. Jade Jaws picks up a tank (50,000 kg!) and throws it at an angle of 45 degrees and a speed of 40 m/s onto a mesa 25 meters higher than where he is standing. Using energy principles, how fast does the tank hit the ground?

3. **Wonder Woman Deflects Bullets.**
   Every superhero needs a way to deal with bullets. Wonder Woman uses her bracelets to deflect them. If a 5 gram bullet heads toward her at 300 m/s and is deflected by 45 degrees back in the direction it came from (I'll draw a diagram), at a speed of 200 m/s. What is the impulse of the net force? If the bullet is in contact with the bracelet for 0.0010 seconds, what is the average force applied to deflect it?

4. **Supergirl Tackles Darkseid.**
   The super-villain Darkseid is threatening Earth…again. Supergirl tries to take him out. She flies into him at 1000 m/s (faster than a speeding bullet!) and grabs on, looking to slam him into a wall. Assume she has a mass of 60 kg, and he has a mass of 200 kg. If we ignore any non-physical superpowered flying effects after the impact, what is the final kinetic energy and linear momentum of the pair before they hit the wall? How does these compare to their initial values (a ratio is preferred)?

5. **Captain America Throws a Shield.**
   Captain America throws his shield like a discus at the Winter Soldier. The shield moves at 30 m/s and spins at a rate of 10 radians per second. The shield has a mass of 10 kg and a radius of 0.40 m. Treating the shield like a solid cylinder, what is the total kinetic energy of the shield? What is its linear and angular momenta?

6. **Quicksilver exercises in a giant hamster wheel.**
   Quicksilver, who will appear in the next Avengers movie, runs without slipping in a giant hamster wheel, which we can approximate as a hollow cylinder with a radius of two meters and a mass of 300 kg. After ten seconds, the angular velocity is 100 radians per second. What is his linear velocity relative to the wheel's surface? What was his angular acceleration, assuming it was constant? What is the kinetic energy of the wheel? How much work has he done?

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

Hook's Law:

F = kx (where k is the spring constant)

Kinetic Energy:

K = ½ mv^2 (linear)
K = ½ I w^2 (rotational)

Potential Energy:

U = mgh (gravitational)
U = ½ 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:

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

Impulse and Impulse-Momentum Theorem:

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

Angular-Linear Relationships:

a = v^2/r (uniform circular motion)
v = rω, a_{tan} = rα, and a_{rad} = v^2/r = rω

Parallel axis theorem for the moment of inertia I:

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

Angular dynamics:

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

Angular Momentum:

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

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
$a_x = \text{constant}$	$\alpha_z = \text{constant}$
$v_x = v_{0x} + a_x t$	$\omega_z = \omega_{0z} + \alpha_z t$
$x = x_0 + v_{0x}t + \frac{1}{2}a_x t^2$	$\theta = \theta_0 + \omega_{0z}t + \frac{1}{2}\alpha_z t^2$
$v_x^2 = v_{0x}^2 + 2a_x(x - x_0)$	$\omega_z^2 = \omega_{0z}^2 + 2\alpha_z(\theta - \theta_0)$
$x - x_0 = \frac{1}{2}(v_x + v_{0x})t$	$\theta - \theta_0 = \frac{1}{2}(\omega_z + \omega_{0z})t$