Practice Final Exam (Brotherton)

Phys 1210 (Ch. 1-10, 12-13) _______

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's the boss. When the Hulk jumps to attack Godzilla, Godzilla sends him flying. If the Hulk is knocked back at an upward angle of 30 degrees at a speed of 200 m/s, from a height of 100 meters, how far away in (horizontal) meters does he land from Godzilla?

2. **Captain America chases an agent of Hydra.**
   Captain America uses his shield to slide down the railing of a stairwell in pursuit of a bad guy. Assuming he starts at zero velocity, has a mass of 100 kg, the coefficient of kinetic friction is 0.2, the angle of the railing is 45 degrees, and the change in height is 20 meters from top to bottom, how long does it take him to reach the bottom?

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?

4. **Quicksilver hits Spider-man…a lot.**
   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 circuit. Ouch! If Quicksilver is one meter away from Spider-man, and accelerates with a constant linear acceleration of 10 m/s^2 for 10 seconds, what is his final linear speed in m/s? His final kinetic energy (assuming a mass of 70 kg) in Joules? How many times has he hit poor Spider-man?

5. **The Joker's Giant Yo-Yo Trap.**
   Batman is investigating an airplane hanger looking for clues, but accidently sets off a trap designed to squash him. The Joker has wrapped a cable around a solid cylinder (mass 100 kg, radius 1 meter) to create a makeshift yo-yo and attached it to the ceiling 12 meters above the floor. Assuming Batman is two meters tall (his bat ears stick up), so the drop is ten meters total, at what speed will the unwinding yo-yo hit him on the head? Assume 10 m/s^2 for the acceleration due to gravity, and that Batman won't dodge at the last moment (a poor assumption!).

6. **The Vision flies!**
   The superhero Vision from the last Avengers movies flies by controlling his density. Somehow he can change his mass and become buoyant, enabling flight in air. If he changes his density to ½ that of air (which is 1.2 kg/m^3), what is his acceleration upward? After five seconds, what is his velocity? How high has he gone? Assume this is on Earth, and the Vision has a volume of 0.1 cubic meters.

7. **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 $5.97\text{x}10^{24}$ kg.

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 $\boldsymbol{W = \overrightarrow{F} \cdot \overrightarrow{s} = Fs\cos\phi}$
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:

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

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)
$v = r\omega$, $a_{tan} = r\alpha$, 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 $\vec{\tau} = \vec{r} \, X \, \vec{F}$ **and** $\sum \tau_z = I\alpha_z$

Angular Momentum:

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

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)** $= 2 \pi r^{3/2}/\text{sqrt}(Gm_E)$
$G = 6.67\text{x}10^{-11}$ $N\cdot(m/kg)^2$

Periodic Motion

$f = 1/T$; $T= 1/f$
$\omega = 2\pi f = 2\pi/T$ **(angular frequency here)**
$\omega = \text{sqrt}(k/m)$ **(k is spring constant)**
$x = A \cos(\omega t + \Phi)$
$\omega = \text{sqrt} (\kappa/I)$ **(angular harmonic motion)**
$\omega = \text{sqrt} (g/L)$ **(simple pendulum)**
$\omega= \text{sqrt} (mgd/I)$ **(physical pendulum)**

Mechanical Waves in General

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

Sound Waves

$P_{max} = BkA$ **(B is bulk modulus)**
$B = (10 \text{ dB}) \log(I/I_0)$ **where** $I_0 = 1\text{x}10^{-12}$ 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
$a_x = \text{constant}$	$\alpha_z = \text{constant}$
$v_x = v_{0x} + a_x t$	$\omega_z = \omega_{0z} + \alpha_z t$
$x = x_0 + v_{0x}t + \frac{1}{2}a_x t^2$	$\theta = \theta_0 + \omega_{0z}t + \frac{1}{2}\alpha_z t^2$
$v_x^2 = v_{0x}^2 + 2a_x(x - x_0)$	$\omega_z^2 = \omega_{0z}^2 + 2\alpha_z(\theta - \theta_0)$
$x - x_0 = \frac{1}{2}(v_x + v_{0x})t$	$\theta - \theta_0 = \frac{1}{2}(\omega_z + \omega_{0z})t$