Practice Final Exam (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 problems. Calculators are allowed.

Tips for better exam grades:

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. **Dr. Who is (Temporarily) Lost in Space.**
   In a classic Dr. Who episode, The Doctor finds himself in space without a spacesuit some distance from a spacecraft airlock, with a relative velocity of zero. Luckily, he finds a cricket ball in his pocket. A cricket ball has a mass of 156 grams. He throws the ball at 20 m/s away from the spacecraft. If the Doctor masses 80 kilograms, how fast does he move toward the spacecraft in m/s after the throw?

4. **Hit Girl Drops In.**
   Hit Girl rides in a bucket down into a warehouse where there is criminal activity to destroy. She masses 40 kg. The bucket is connected by a rope to an unwinding spool (that can be treated as a solid cylinder) of mass 50 kg and a radius of 0.5 meters. Ignore the mass of the rope and the bucket. If the roof is 20 meters above the floor, how long does it take her?

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. **Spider-man on Web (SHO).**
   Spider-man is swinging back and forth with his camera set up to let Peter Parker earn some money for photos by selling them to the Daily Bugle. If his web is 30 meters long, and his swing back and forth only makes small angles, what time delay should be set on his camera to get a picture every time he swings by at the lowest point of the swing?

7. **Black Canary's Cry.**
   While the Black Canary prefers hand-to-hand combat, she possesses a powerful "Canary Cry" cable 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 $W = \vec{F} \cdot \vec{s} = Fs\cos\phi$
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:

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

Gravity:

$F = Gm_1m_2/r^2$
$U = -Gm_Em/r$
T (orbital period) $= 2\pi r^{3/2}/\sqrt{Gm_E}$
$G = 6.67\times10^{-11}$ N·(m/kg)^2

Periodic Motion

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

Mechanical Waves in General

$V = \lambda f$
$Y(x,t) = A\cos(kx - \omega t)$ (k is wavenumber, k = $2\pi f$)
$V = \sqrt{F/\mu}$
$P_{av} = \frac{1}{2}\sqrt{\mu F}\,\omega^2 A^2$
$I_1/I_2 = (r_2/r_1)^2$ (inverse square law for intensity)

Sound Waves

$P_{max} = BkA$ (B is bulk modulus)
$B = (10\text{ dB})\log(I/I_0)$ where $I_0 = 1\times10^{-12}$ W/m^2

Table 9.1 Comparison of Linear and Angular Motion with Constant Acceleration

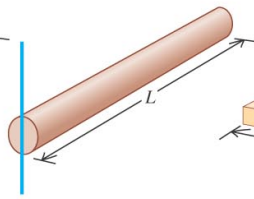| Straight-Line Motion with Constant Linear Acceleration	Fixed-Axis Rotation with Constant Angular Acceleration
$a_x = \text{constant}$	$\alpha_z = \text{constant}$
$v_x = v_{0x} + a_x t$	$\omega_z = \omega_{0z} + \alpha_z t$
$x = x_0 + v_{0x}t + \frac{1}{2}a_x t^2$	$\theta = \theta_0 + \omega_{0z}t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

(a) Slender rod, axis through center
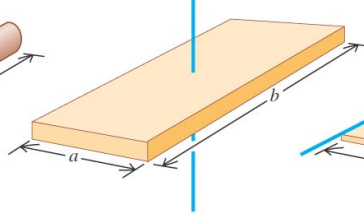
$$I = \frac{1}{12}ML^2$$
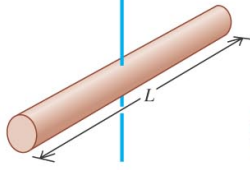
(b) Slender rod, axis through one end
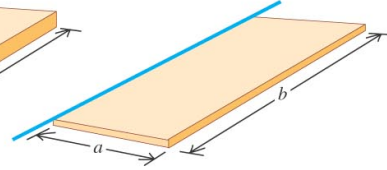
$$I = \frac{1}{3}ML^2$$

(c) Rectangular plate, axis through center

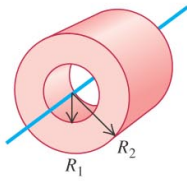$$I = \frac{1}{12}M(a^2 + b^2)$$

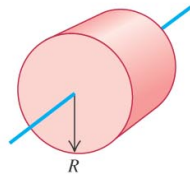**(d)** Thin rectangular plate, axis along edge

$$I = \frac{1}{3}Ma^2$$
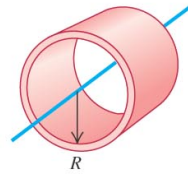
(e) Hollow cylinder

$$I = \frac{1}{2}M(R_1^2 + R_2^2)$$
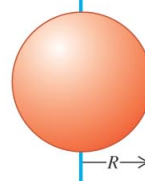
(f) Solid cylinder

$$I = \frac{1}{2}MR^2$$

(g) Thin-walled hollow cylinder

$$I = MR^2$$

(h) Solid sphere

$$I = \frac{2}{5}MR^2$$

(i) Thin-walled hollow sphere

$$I = \frac{2}{3}MR^2$$