Sp 2015 Practice Exam 1 (Brotherton)

Phys 1210 (Ch. 1-5) ________

your name

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

You can skip one of the problems (best five will count if you do all 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. **Spider-man's web.**
   Spider-man and his Amazing Friend Iceman are trying to stop the Rhino's rampage. The Rhino gets stuck on a frictionless patch of ice. Spider-man secures him in place with three web lines. The first webline has a tension of 400N due North. The second is due Southwest with a tension of 300N. What must be the direction and tension of the third webline to keep the Rhino in the same location?

2. **A "Fastball Special" from the X-Men.**
   A battle tactic used by the X-Men is for Colossus to throw Wolverine at a foe, which he is very likely to hurt. Colossus wants to throw Wolverine at an approaching Sentinel robot's head, which is 8 meters above the ground. If the Sentinel is 50 meters away, and Colossus throws Wolverine at an angle of 30 degrees upward from the horizontal, how fast must the "fastball special" be to hit the target?

3. **Captain America and the Falcon fight Batroc the Leaper**
   The Falcon is flying due South, at 30 m/s relative to the ground, carrying Captain America with him. Captain America throws his shield southwest, at 20 m/s relative to the Falcon. If Batroc is leaping at 10 m/s due West, what is the velocity of the shield when it hits him?

4. **Batman saves Batgirl and Robin**
   Batman is standing stationary on a rooftop holding a bat cable that is slung over a gargoyle (treat as a frictionless pulley). On the other end of the cable hangs Batgirl. She in turn is holding a second bat cable from which Robin dangles beneath her. Assume Batman has a mass of 150 kg (it's a big utility belt!), and that Batgirl and Robin have masses of 50 kg each. Furthermore, Batman's boots have a coefficient of static friction of 0.8. A) What is the tension in the bat cable Batman holds? B) What is the tension in the cable Robin holds?

5. **The Black Widow slides down a Hill**
   The Black Widow attacks a terrorist camp. She slides 100m down along a very steep hill (60 degrees incline). Her mass is 50 kg. The coefficient of kinetic friction between her and the hillside is 0.3. Ignore air resistance. A) What is her acceleration? B) How fast is she moving at the bottom of the hill assuming her initial velocity was zero?

6. **Superman races the Flash.**
   Superman and the Flash run the first part of their race at a constant velocity of 400 m/s (which is about 900 mph). Then the Flash decides to leave Superman in the dust and increasingly accelerates for 10 seconds according to the formula $a=10t^2$ m/s^4 (where we start at t=0 when the acceleration begins). Ignore the wind resistance and any potential relativistic effects. A) At the end of the ten seconds, how fast is the Flash traveling? B) How many meters has he traveled over the course of these 10 seconds?

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)

$v = r\omega$, $a_{tan} = r\alpha$, 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:

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

Gravity:

$F = Gm_1m_2/r^2$

$U = -Gm_Em/r$

T (orbital period) = $2 \pi r^{3/2}/\text{sqrt}(Gm_E)$

$G = 6.67 \times 10^{-11}$ 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

$V = \lambda f$

$Y(x,t) = A \cos(kx - \omega t)$ (k is wavenumber, $k = 2\pi f$)

$V = \text{sqrt}(F/\mu)$

$P_{av} = ½ \text{ sqrt}(\mu F)\ \omega^2 A^2$

$I_1/I_2 = (r_2/r_1)^2$ (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
$a_x = \text{constant}$	$\alpha_z = \text{constant}$
$v_x = v_{0x} + a_x t$	$\omega_z = \omega_{0z} + \alpha_z t$
$x = x_0 + v_{0x}t + \frac{1}{2}a_x t^2$	$\theta = \theta_0 + \omega_{0z}t + \frac{1}{2}\alpha_z t^2$
$v_x^2 = v_{0x}^2 + 2a_x(x - x_0)$	$\omega_z^2 = \omega_{0z}^2 + 2\alpha_z(\theta - \theta_0)$
$x - x_0 = \frac{1}{2}(v_x + v_{0x})t$	$\theta - \theta_0 = \frac{1}{2}(\omega_z + \omega_{0z})t$