Practice Exam 1 Fall 2017 (Brotherton)

Phys 1210 (Ch. 1-4) ___________

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 toward the center of the Earth as the acceleration due to gravity on Earth, but use two significant figures for such problems

'Nuff said.

1. **The Guardians of the Galaxy land on a new planet.** Gamora drops her big knife, which masses 500 grams, from a height of one meter. It takes one second to fall to the ground. Ignoring air resistance, what is the acceleration due to gravity on this world?

2. **Hulk Throws a Tantrum (and a Tank).** The incredible Hulk is 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 flat mesa 25 meters higher than his position. A) What is the time in seconds when it lands? B) How far away does it land? That is, what is the x-displacement in meters?

3. **Hawkeye and Loki.** Hawkeye is standing on top of a building and shoots an arrow at Loki due North at a velocity of 100 m/s. Loki is flying in an alien craft at the same height Northwest at a velocity of 40 m/s. What is the relative velocity (e.g., speed and direction) of the arrow as seen by Loki?

4. **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?

5. **Ironman restarting the SHEILD Helicarrier turbine.** The diameter of the turbines on the SHIELD Helicarrier are about 52 meters. The rotation rate of the blades is about 1.3 times per second when they are ramped up. If Ironman in his armor has a mass of 180 kg, what centripetal thrust (force) must he supply to keep his flight path turning as he forces the blades to turn at full speed? Only consider the component of his thrust toward the center of the turbine, and ignore any other part. Remember you've been given a diameter, not a radius.

6. **Ms. Marvel flying.** Ms. Marvel takes off, accelerating up according to the formula $a = 2\ m/s^2 + 10\ m/s^4\ t^2$ for ten seconds. (This formula describes her observed acceleration and we need not add effects of gravity, since they are included already.) At the end of ten seconds, what is her velocity in m/s? How far has she traveled in 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	

Friction:

$F = -\mu_k * n$ (kinetic)
$F < -\mu_s * n$ (static upper limit)

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:

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

Center of Mass:

$$\vec{r}_{cm} = \frac{\sum_i m_i r_i}{\sum_i m_i}$$

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
$\omega = 2\pi f = 2\pi/T$ (angular frequency here)
ω = sqrt(k/m) (k is spring constant)
$x = A \cos(\omega t + \Phi)$
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 = sqrt (F/μ)
P_{av} = ½ sqrt(μF) $\omega^2 A^2$
$I_1/I_2 = (r_2/r_1)^2$ (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

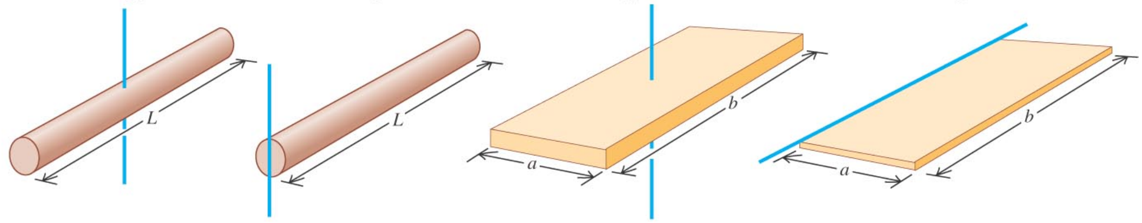
Straight-Line Motion with Constant Linear Acceleration	Fixed-Axis Rotation with Constant Angular Acceleration
$a_x = \text{constant}$	$\alpha_z = \text{constant}$
$v_x = v_{0x} + a_x t$	$\omega_z = \omega_{0z} + \alpha_z t$
$x = x_0 + v_{0x}t + \frac{1}{2}a_x t^2$	$\theta = \theta_0 + \omega_{0z}t +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

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