MIDTERM EXAM-3 – v1

PHYS 201 (Spring 2018), 04/03/18

Name:

Last 4 digits of UIN:

Lab-Sect. no.:

Signature:

In taking this exam you confirm to adhere to the Aggie Honor Code:
"An Aggie does not lie, cheat, steal or tolerate those who do."

Duration: 90 minutes
Show all your work for full/partial credit!
Include the correct units in your final answers for full credit!
Unless otherwise stated, quote your results in SI units!

1.) *Multiple Choice* *(21 pts.)*

For each statement below, circle the correct answer (A, B or C, no reasoning required).

(a) A car tire rotating at an angular speed of 37.7 rad/s completes
(A) 6 (B) 8 (C) 12
revolutions per second.

(b) When a solid cylinder ($I = \frac{1}{2}MR^2$) and a solid sphere ($I = \frac{2}{5}MR^2$), both starting from rest, roll down an inclined plane (without slipping) in a race,
(A) the cylinder wins (B) the sphere wins (C) it's a tie.

(c) If the net force on an extended rigid object is zero, the net torque
(A) must also be zero (B) could be non-zero (C) must be non-zero.

(d) When you drive a bike along a straight-line horizontal road, the angular momentum of the wheels points
(A) straight ahead (B) straight up (C) sideways.

(e) The center-of-mass and the center-of-gravity of an object
(A) are at the same point (B) are at different points (C) can be either way.

(f) When you increase the amplitude of a simple harmonic motion, the frequency of the motion
(A) increases (B) stays the same (C) decreases.

(g) When you double the maximal speed in a simple harmonic motion, its amplitude
(A) doubles (B) triples (C) quadrupels.

No.	Points
1	
2	
3	
4	
5	
Sum	

2.) *Rolling Motion and Kinetic Energies* *(20 pts.)*

A car tire (approximated as a solid cylinder of radius $35\,cm$ and mass $5\,kg$) is rolling downhill without slipping. At a height of 11m above the bottom of the hill, it has a translational speed of $8\,m/s$. Neglect friction.

(a) Calculate the total kinetic energy of the tire at the bottom of the hill.

(b) Calculate the angular and translational speed of the tire at the bottom of the hill.

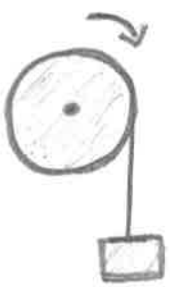
3.) *Rotational Dynamics and Kinematics* *(24 pts.)*

A box of mass mass $3\,kg$ is tied to a massless rope which is wrapped around the outer rim of a solid cylindrical pulley (radius $30\,cm$, mass $14\,kg$). The pulley is free to rotate about the axis through its center. The system is released from rest; neglect friction.

(a) Draw a free-body diagram and write down Newton's 2. law of motion for the pulley and for the box.

(b) Find the angular acceleration of the pulley.

(c) After how many seconds has the pulley reached an angular speed of $10\,rad/s$?



4.) *Angular Momentum Conservation* *(18 pts.)*

A bullet (mass 60 g, initial speed 200 m/s) is shot horizontally at a uniform wooden cylinder (mass 12 kg, radius 0.5 m) which is free to rotate about a fixed axis through its center. The path of the bullet has a distance of closest approach to the cylinder axis of 0.3 m, see the sketch below. Neglect gravity.

(a) What is the magnitude of the angular momentum of the bullet before hitting the cylinder, relative to the axis of rotation of the cylinder?

(b) Once the bullet gets stuck in the cylinder at a distance of 0.3 m from the axis, what is the angular speed of the cylinder+bullet?

5.) *Simple Harmonic Motion* *(18 pts.)*

A harmonic oscillator consists of a block (mass $2\,kg$) attached to a horizontal spring on a frictionless horizontal surface. The period of the motion is $1.3\,s$, with a maximal speed of $0.45\,m/s$ of the block.

(a) Calculate the spring constant.

(b) Calculate the amplitude of the motion.

PHYS 201 Formula Sheet

Chapters 1—5 (Exam 1)

Constant acceleration equations:

$$v_x = v_{0x} + a_x t \qquad x = x_0 + v_{0x}t + \tfrac{1}{2}a_x t^2$$

$$v_x^2 = v_{0x}^2 + 2a_x(x - x_0) \qquad x - x_0 = \left(\frac{v_{0x} + v_x}{2}\right)t$$

$$g = 9.80\ \text{m/s}^2 \qquad w = mg$$

$$\sum F_x = ma_x \qquad \sum F_y = ma_y$$

$$f_\text{k} = \mu_\text{k} n \qquad f_\text{s} \le \mu_\text{s} n$$

$$F_\text{spr} = -kx$$

quadratic formula: The equation $ax^2 + bx + c = 0$ has solutions $x = \dfrac{-b \pm \sqrt{b^2 - 4ac}}{2a}$.

Chapters 6—8 (Exam 2)

$$a_\text{rad} = \frac{v^2}{R} \qquad v = \frac{2\pi R}{T}$$

$$F_\text{g} = G\frac{m_1 m_2}{r^2} \qquad G = 6.67\times10^{-11}\ \text{N}\cdot\text{m}^2/\text{kg}^2 \qquad T = \frac{2\pi r^{3/2}}{\sqrt{Gm_\text{E}}}$$

$$W = F_\parallel s = (F\cos\phi)s \qquad W_\text{total} = K_\text{f} - K_\text{i} = \Delta K$$

$$U_\text{grav} = mgy \qquad K = \tfrac{1}{2}mv^2 \qquad U_\text{el} = \tfrac{1}{2}kx^2$$

$$K_\text{f} + U_\text{f} = K_\text{i} + U_\text{i} + W_\text{other}$$

$$P_\text{av} = \frac{W}{t} \qquad P = F_\parallel v$$

$$\vec{p} = m\vec{v} \qquad \Delta\vec{p} = \vec{F}_\text{av}(t_\text{f} - t_\text{i}) = \vec{J}$$

$$x_\text{cm} = \frac{m_A x_A + m_B x_B + m_C x_C + \ldots}{m_A + m_B + m_C + \ldots} \qquad y_\text{cm} = \frac{m_A y_A + m_B y_B + m_C y_C + \ldots}{m_A + m_B + m_C + \ldots}$$

$$v_{\text{cm},x} = \frac{m_A v_{A,x} + m_B v_{B,x} + m_C v_{C,x} + \ldots}{m_A + m_B + m_C + \ldots} \qquad v_{\text{cm},y} = \frac{m_A v_{A,y} + m_B v_{B,y} + m_C v_{C,y} + \ldots}{m_A + m_B + m_C + \ldots}$$

$$M\vec{v}_\text{cm} = \vec{P} \qquad \sum \vec{F}_\text{ext} = m\vec{a}_\text{cm}$$

PHYS 201 Formula Sheet **Chapters 9—11 (Exam 3)**

For constant α:

$$\omega = \omega_0 + \alpha t \qquad \omega^2 = \omega_0^2 + 2\alpha(\theta - \theta_0)$$

$$\theta - \theta_0 = \omega_0 t + \tfrac{1}{2}\alpha t^2 \qquad \theta - \theta_0 = \left(\frac{\omega + \omega_0}{2}\right)t$$

$$s = r\theta \qquad v = r\omega \qquad a_{\text{tan}} = r\alpha \qquad a_{\text{rad}} = v^2 / r = r\omega^2$$

$$K = \tfrac{1}{2}I\omega^2 \qquad I = m_A r_A^2 + m_B r_B^2 + \ldots. \qquad U = Mgy_{\text{cm}}$$

$$K_{\text{total}} = \tfrac{1}{2}Mv_{\text{cm}}^2 + \tfrac{1}{2}I_{\text{cm}}\omega^2$$

$$\tau = Fl \qquad \sum \tau = I\alpha \qquad \Delta W = \tau\Delta\theta \qquad P = \tau\omega \qquad L = I\omega$$

$$\sum \tau = \frac{\Delta L}{\Delta t} \qquad L = mvl$$

first and second conditions for equilibrium:
$\sum F_x = 0$, $\sum F_y = 0$ and $\sum \tau = 0$ (any axis)

$$Y = \frac{F_\perp / A}{\Delta l / l_0} \qquad B = -\frac{\Delta p}{\Delta V / V_0} \qquad S = \frac{F_\parallel / A}{x / h} = \frac{F_\parallel / A}{\phi}$$

$$F_x = -kx \qquad a_x = -\frac{k}{m}x \qquad \omega = 2\pi f \qquad f = \frac{1}{T}$$

$$U_{\text{el}} = \tfrac{1}{2}kx^2 \qquad K = \tfrac{1}{2}mv^2$$

$$x = A\cos\omega t \qquad v_x = -\omega A \sin\omega t \qquad \omega = \sqrt{\frac{k}{m}} \qquad f = \frac{1}{2\pi}\sqrt{\frac{k}{m}} \qquad T = 2\pi\sqrt{\frac{m}{k}}$$

$$f = \frac{1}{2\pi}\sqrt{\frac{g}{L}} \qquad T = 2\pi\sqrt{\frac{L}{g}}$$

Moments of inertia:
rotating point mass $I = MR^2$, solid cylinder $I = \frac{1}{2}MR^2$, solid sphere $I = \frac{2}{5}MR^2$