Physics 206 – Comprehensive Exam

Spring 2019 (all UP sections) April 26$^{\text{th}}$, 2019

Please fill out the information and read the instructions below, but **do not open the exam** until told to do so.

Rules of the exam:

1. You have 120 minutes (2 hrs) to complete the exam.
2. Formulae are provided to you with the exam on a separate sheet. Make sure you have one before the exam starts. You may *not* use any other formula sheet.
3. Check to see that there are 8 numbered (4 double-sided) pages in addition to the scantron-like cover page. **Do not remove any pages**.
4. If you run out of space for a given problem, the last two pages have been left blank and may be used for extra space. Be sure to indicate *at the problem under consideration* that the extra space is being utilized (and also on the extra sheets, which problem the work refers to) so the graders know to look at it!
5. Calculators of any type are **not allowed**. In the case of questions with numerical values, the math should be simple enough you will not need a calculator. For purely symbolic questions, ensure that all your answers are in terms of the known variables given in the question.
6. Cell phone use during the exam is strictly prohibited. Please turn off all ringers as calls during an exam can be quite distracting.
7. Be sure to put a box around your $\boxed{\text{final answer(s)}}$ and clearly indicate your work. Credit can be given **only** if your work is legible, clearly explained, and labelled.
8. Unless explicitly stated otherwise in the question, all of the free-response problems in this exam require you show your work and reasoning.
9. Have your TAMU ID ready when submitting your exam to the proctor.

Fill out the information below and sign to indicate your understanding of the above rules

Name: ______________________________ UIN: ______________________________
(printed *legibly*)

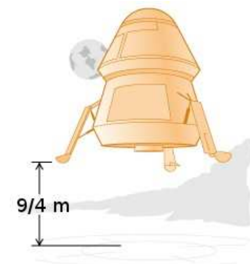
Signature: ______________________________ Section Number: ____________________

Instructor: (circle one)

Allen	Eusebi	Kocharovsky	Kubik
Mahapatra	McIntyre	Saslow	Wu

Short Problems:

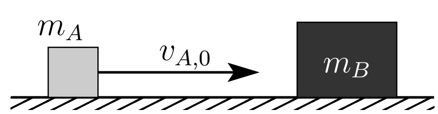
A) A lunar lander is making its descent to Moon Base I. The lander descends slowly under the retro-thrust of its descent engine. The engine is cut off when the lander is $\frac{9}{4} = 2.25$ m above the surface and has a downward speed of 4 m/s. The acceleration due to gravity on the moon can be assumed to be 2 m/s^2. With the engine off, the lander is in free fall. How long would it take the lander to reach the surface of the moon after the engines were cut off?



LO	S	U
5.1		
14.1		

Ans: ______________________________

B) Block A on the left has mass $m_A = 1$ kg. Block B on the right has mass $m_B = 3$ kg. Block A is initially moving to the right at $v_{A,0} = 6$ m/s, while block B is initially at rest. The surface they move on is level and frictionless.



(a) What is the velocity of the center of mass of the two blocks *before* the blocks collide?

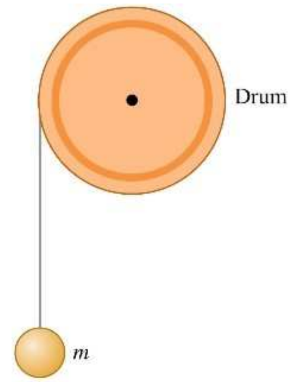
Ans: ______________________________

(b) If the two blocks stick together following the collision, determine the impulse imparted on block B by the block A.

LO	S	U
45.1		
48.1		
49.1		

Ans: ______________________________

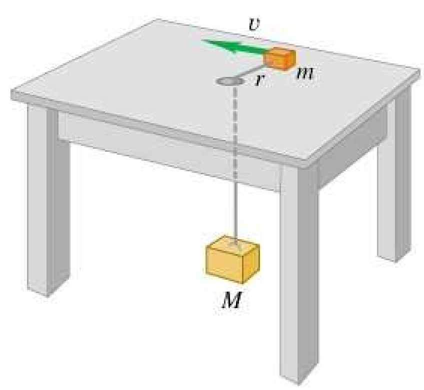
C) A thin, very light wire is wrapped around a drum that is free to rotate. The free end of the wire is attached to a ball of mass m. The drum is a solid disk with mass m and radius R. As the ball falls, the drum spins. At an instant that the ball has translational kinetic energy K, what is the rotational kinetic energy of the drum?



Ans: ______________________________

LO	S	U
16.1		
34.1		
35.1		
51.1		

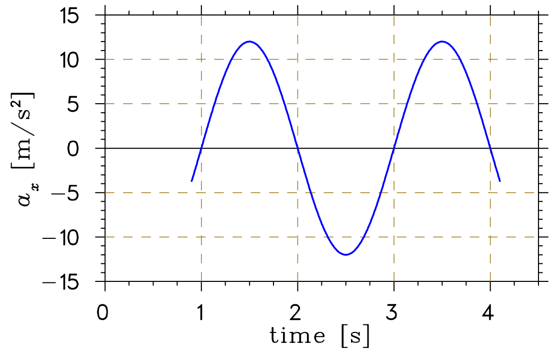
D) A small block with mass m moves in a circular path on a frictionless horizontal tabletop a distance r from a hole in the center of the table. The block is attached by a massless rope through the hole to another block of larger mass M on the other end of the rope (as shown in the figure). There is no friction between the rope and the hole in the table. What speed v must the small block have if the large block is to remain motionless?



Ans: ______________________________

LO	S	U
18.1		
21.1		
23.1		
24.1		

E) This is an a_x-t graph for an object in simple harmonic motion.



(a) What is the earliest time at which the object has the *most negative displacement*, x?

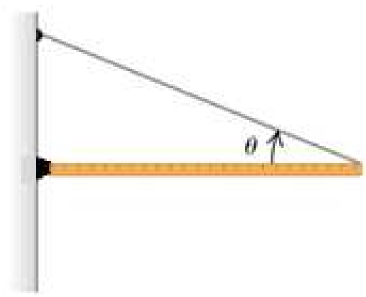
Ans: ____________________

(b) What is the earliest time at which it has the *most negative velocity*?

LO	S	U
66.1		
66.2		

Ans: ____________________

F) A uniform rod of mass m and length L is hinged on the vertical wall and is held by a rope, as shown. The cable snaps, causing the rod to swing down around the hinge.



(a) Find the torque acting on the rod when the cable snaps.

Ans: ____________________

(b) Find the angular acceleration of the rod when the cable snaps.

Ans: ____________________

(c) Find the direction of the angular acceleration.

LO	S	U
54.1		
51.2		
55.1		
55.2		

Ans: ____________________

Prob 1 An astronaut lands on planet Suffrin of known radius R. She throws a rock to a height H directly above her hand ($H \ll R$), and she catches it after T seconds.

(a) Find the acceleration due to gravity on the surface of Suffrin, in terms of H and T.

Ans: ____________________________

(b) Find Suffrin's mass, M_S, in terms of H, T, R and the gravitational constant, G.

Ans: ____________________________

(c) Find the velocity of Suffrin's moon Succotash, moving about Suffrin in a circle of radius $10R$. Express the velocity in terms of R, Suffrin's mass M_s, and the gravitational constant G.

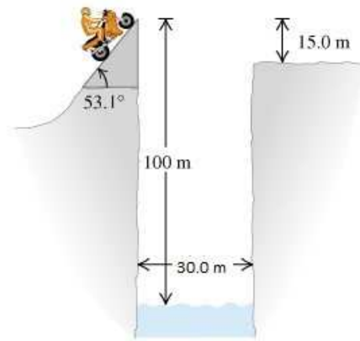
Ans: ____________________________

(d) How long does it take for Succotash to complete one revolution around Suffrin?

LO	S	U
14.2		
21.2		
60.1		
18.2		
60.2		
19.1		
60.3		

Ans: ____________________________

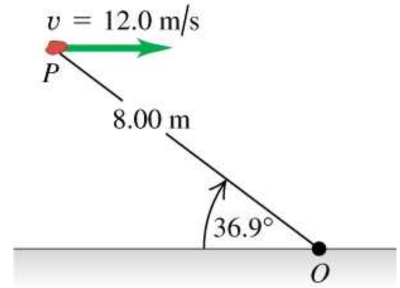
Prob 2 A physics student's last daredevil stunt was an attempt to jump across a 30-m wide river on a motorcycle. The takeoff ramp was inclined at 53.1° and the far bank was 15.0 m below the top of the ramp. The river itself was 100 m below the ramp. Ignore air resistance and take $g = 10$ m/s. What should his speed have been at the top of the ramp to have just made it to the edge of the far bank?



Ans: ______________________________

LO	S	U
14.3		
15.1		
3.1		
14.4		
15.2		

Prob 3 A 5 kg rock has a horizontal velocity of 12 m/s when it is at point P in the figure. Answer the following questions when the rock is at point P.



(a) Draw a coordinate system.

(b) What is the magnitude of its angular momentum relative to point O?

Ans: ____________________

(c) What is the direction of the angular momentum in part (b)?

Ans: ____________________

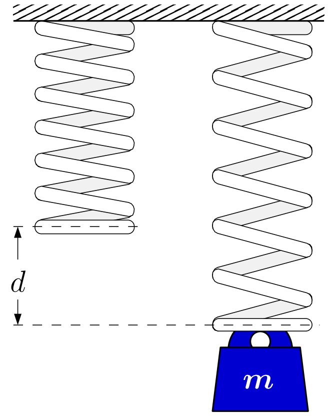
(d) If the only force acting on the rock is its weight, what is the magnitude of the rate of change of its angular momentum?

Ans: ____________________

(e) What is the direction of the rate of change of the rock's angular momentum in part (d)?

Ans: ____________________

LO	S	U
9.1		
57.1		
57.2		
54.2		
58.1		
54.3		



Prob 4 A mass m attached to the bottom of a vertical spring and allowed to come to equlibrium. It is observed that the mass stretched the spring by a distance d.

(a) What is the force constant k of the spring?

Ans: ______________________________

(b) Find the time period T for the oscillation of the mass m on this spring.

Ans: ______________________________

(c) At $t = 0$ the mass M passes through equilibrium, moving downward. In what direction (upward or downward) is it moving at $t = T/6$?

Ans: ______________________________

(d) If the amplitude of the motion is A, what is its speed at $t = T/6$?

Ans: ______________________________

(e) What is the maximum energy stored in the spring?

Ans: ______________________________

(f) If we want to double the period to $2T$, what mass, M, should we attach to the spring? Answer in terms of the original mass, m.

Ans: ______________________________

LO	S	U
21.3		
23.2		
25.1		
66.3		
66.4		
66.5		
38.1		
66.6		
66.7		

Extra space: