Physics 218 – Comprehensive Exam

Fall 2018 (all UP sections) November 30$^{\text{th}}$, 2018

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 (four 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, as the proctor for an extra sheet of paper. Ensure you write you name, section and UIN on the extra sheet, and be sure to indicate *at the problem under consideration* that the extra space is being utilized 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 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. You do **not** need to show your work for the multiple-choice problems.
9. Have your TAMU ID ready when submitting your exam to the proctor.
10. **Make sure you filled out all the bubbles on the scantron-like page!**

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

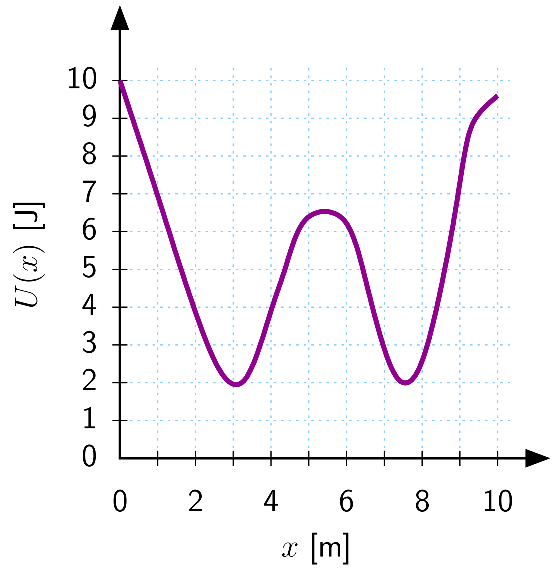
PRINTED Name: ______________________ UIN: ______________________
(printed *legibly*)

Signature: ______________________ Section Number: ______________

Instructor: (circle one) Kocharovsky Melconian

Short Problems:

A) Consider the potential as a function of x as shown in the figure below. A particle is placed at $x = 3$ m with 2.5 J of translational kinetic energy.



(i) What is the range in x of the particle in this potential, $U(x)$?

Ans: ____________________________

(ii) Based on what is shown of this potential, $U(x)$, what direction ($+\hat{\imath}$ or $-\hat{\imath}$) is the corresponding force, F_x, when $x > 8$ m?

Ans: ____________________________

(iii) Identify the two points of stable equilibrium and the one point of unstable equilibrium by drawing labelled arrows directly on the figure.

LO	S	U
41.1		
43.1		
37.1		
44.1		
37.2		
42.1		
42.2		
42.3		

B) The International Space Station (ISS) is in uniform circular motion at an altitude h above the Earth. Answer the following in terms of the altitude, the radius, $R_\oplus$, and mass, $M_\oplus$, of the Earth, and Newton's universal gravitational constant.

(i) Write down Newton's 2^{nd} Law for the ISS and find the centripetal acceleration of the ISS, showing it doesn't depend on mass of the ISS.

(ii) From your answer to (i), find the speed with which the ISS is orbiting Earth.

Ans: ____________________________

(iii) The time it takes for the ISS to complete one orbit.

Ans: ____________________________

LO	S	U
6.1		
21.1		
60.1		
16.1		
18.1		
60.2		
63.1		

C) An object is executing simple harmonic motion. What is true about the acceleration of this object? (There may be more than one correct choice.) Indicate your choices by checking `T` for "true" or `F` for "false".

`T` `F`

☐ ☐ The acceleration is zero when the speed of the object is a maximum.

☐ ☐ The magnitude of acceleration is a maximum when the object is instantaneously at rest.

☐ ☐ The magnitude of acceleration is a maximum when the speed of the object is a maximum.

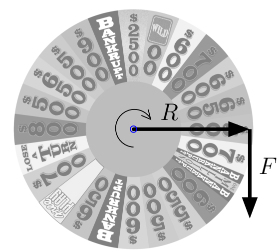
☐ ☐ The magnitude of acceleration is a maximum when the displacement of the object is zero.

☐ ☐ The magnitude of acceleration is a maximum when the magnitude of displacement of the object is a maximum.

LO	S	U
65.1		
65.2		
65.3		

D) You are playing Wheel of Fortune and pull down on the big uniform cylinder of mass M and radius R (take clockwise to be positive, as shown). You apply a constant force F to the edge of the wheel to spin for fortunes. Throughout your pulling on the wheel, you manage to keep the force perpendicular as it rotates. Assume that there is no friction anywhere and that the wheel is at rest before you start pulling.

(i) Find the torque that you apply to the wheel and use it to determine the angular acceleration of the wheel.



Ans: ______________________________

(ii) How much work do you do to the wheel when pulling on it through $\Delta\theta$ radians?

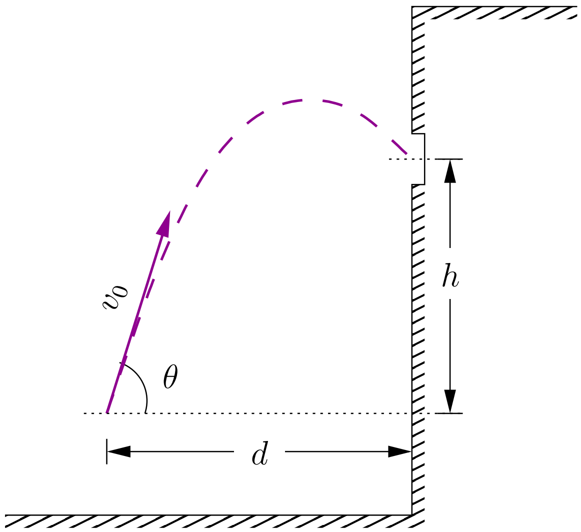
Ans: ______________________________

(iii) Let your answer to (ii) be W_{you}. Using the work-energy theorem, find the angular speed of the wheel when you have pulled it through $\Delta\theta$ radians. Answer in terms of W_{you}, M and R.

Ans: ______________________________

LO	S	U
2.1		
51.1		
54.1		
55.1		
32.1		
6.2		
35.1		
39.1		

E) Romeo throws a rock up at Juliette's window to get her attention late one night. The window is a distance h above his arm when he throws it, he is d away from the wall horizontally, and it takes 1 s for the stone hit the window. Using the $\hat{i}$ direction's equations of motion, find a relationship between the initial speed, v_0 and the direction, θ, and then use the $\hat{j}$ direction to determine v_0 and θ in terms of h, d and g, with $\Delta t = 1$ sec.



LO	S	U
1.1		
4.1		
14.1		
14.2		

Ans: ______________________________

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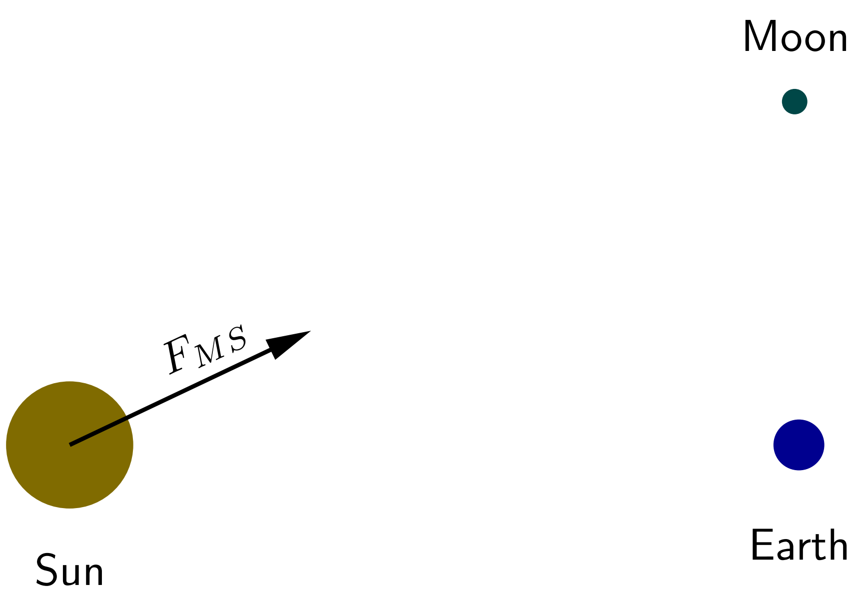
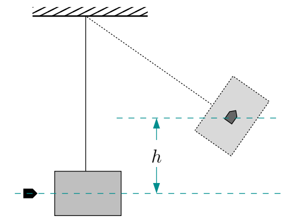
F) Shown is the Sun, Earth and Moon at some particular point in time (not to scale). The force of the Moon on the Sun, F_{MS}, is indicated. In a similar way, sketch and label all other gravitational forces acting between the three objects. Identify all action-reaction pairs by circling your labels and connecting them with a line.



LO	S	U
22.1		
22.2		
22.3		
60.3		
60.4		
60.5		

Prob 1 A 250.0 g missile is fired from a crossbow with a speed of 60 m/s into a pendulum with mass $M = 4.75$ kg, suspended from a cord that is 1.234 m long.



(a) What is the mass of the missile in kg?

Ans: ______________________________

(b) Compute the initial kinetic energy of the missile.

Ans: ______________________________

(c) What is the speed of the missile + pendulum immediately after the missile becomes embedded in the pendulum.

Ans: ______________________________

(d) Compute the kinetic energy of the missile and pendulum immediately after the missile becomes embedded in the pendulum. Is this collision *elastic* or *inelastic*?

Ans: ______________________________

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(e) Compute the maximum vertical height, h, of the centre-of-mass of the pendulum + missile. Your result should be expressed as a fraction of two integers.

Ans: ______________________________

(f) Is angular momentum conserved after the collision as the pendulum rises? (You do not need to justify your answer for this part.)

Ans: ______________________________

LO	S	U
10.1		
34.1		
3.1		
46.1		
46.2		
48.1		
34.2		
50.1		
34.3		
38.1		
40.1		
59.1		

Prob 2 Comet Halley moves in an elongated elliptical orbit around the Sun. The distances of its centre-of-mass from the Sun's centre-of-mass at perihelion and aphelion are R_p and R_a respectively.

(a) What is the orbital semi-major axis, a, of Halley in terms of R_p and R_a?

Ans: ____________________

(b) You're further informed that $R_a \approx 60R_p$. Given this, what is the eccentricity, e, of Halley's orbit? Express your result as a fraction of integers. (Recall $0 \le e \le 1$.)

Ans: ____________________

(c) How much faster is Halley moving at perihelion compared to when it is at aphelion?

Ans: ____________________

(d) What is the magnitude of the gravitational force exerted from the Sun on comet Halley when at perihelion, F_p, compared to when it is at aphelion, F_a, *i.e.* what is F_p/F_a?

Ans: ____________________

LO	S	U
63.2		
64.1		
64.2		
63.3		
64.3		
59.2		
63.4		
60.6		

Prob 3 A toy of mass 2 kg is undergoing simple harmonic motion on the end of a horizontal spring with force constant $k = 1,000$ N/m. When the toy is a distance 0.2 m from its equilibrium position, it is observed to have a speed of 5 m/s.

(a) What is the magnitude of the force that the spring exerts on the toy when it is at $x = +0.2$ m?

Ans: ______________________

(b) Is this force "conservative" or "nonconservative"?

Ans: ______________________

(c) What is the toy's total energy at any point of its motion?

Ans: ______________________

(d) What is the toy's amplitude of the motion?

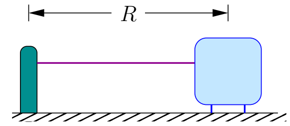
Ans: ______________________

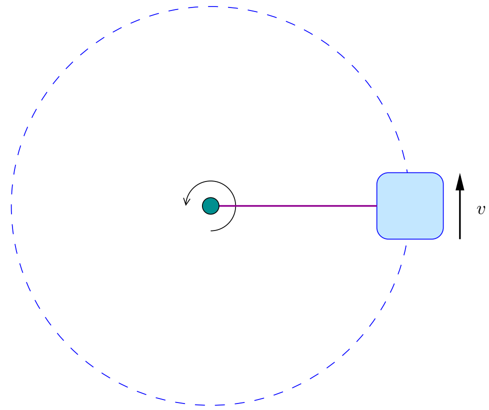
(e) What is the toy's maximum speed during its motion?

Ans: ______________________

LO	S	U
25.1		
36.1		
34.4		
38.2		
40.2		
38.3		
65.4		
34.5		
65.5		

Prob 4 A sled rests on a horizontal sheet of frictionless ice. It is attached by a massless string of length R to a post set in the ice. Once given a push, the sled revolves in a circle around the post with a constant speed v due to a centripetal force exerted by the post on the sled through the tension in the string, T. Express your answers to the following questions in terms of the given quantities R, v, T, and the acceleration due to gravity g.





(a) Draw a free-body diagram for the sled in the figure to the right, and name all forces acting on the sled.

(b) Find the centripetal (perpendicular to $\vec{v}$) and tangential (parallel to $\vec{v}$) components of the sled's acceleration.

Ans: ______________________________

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(c) Write down the Newton's second law for the sled in the radial direction and find the mass of the sled.

Ans: ______________________________

(d) Find the kinetic energy of the sled.

Ans: ______________________________

(e) Is the total mechanical energy of the sled conserved during the uniform circular motion? Is the total angular momentum conserved? (You do not need to justify your answers for this question.)

Ans: ______________________________

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LO	S	U
23.1		
24.1		
26.1		
13.1		
16.2		
17.1		
18.2		
19.1		
6.3		
21.2		
34.6		
39.2		
40.3		
59.3		