Physics 206 – Comprehensive Exam

Fall 2019 (all UP sections)   November 25^{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 3 hrs (180 minutes) 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 10 numbered (5 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 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.

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

MAKE SURE YOU FILL OUT ALL THE BUBBLES ON THE PREVIOUS PAGE BEFORE CONTINUING!!

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

Signature: ______________________ Section Number: ______________

Instructor: Kocharovsky Melconian
(circle one)

Short Problems:

A) Two satellites are in a circular orbit around Mars to study and prepare for colonization. Satellite A orbits with a period T_A. Satellite B is $9\times$ closer taking detailed pictures, and has half the mass of satellite A.

(i) How much work is done on satellite A as it makes on full orbit around Mars?

Ans: ______________________________

(ii) What is the orbital period of satellite B in terms of T_A, satellite A's period?

LO	S	U
32.1		
3.1		
63.1		

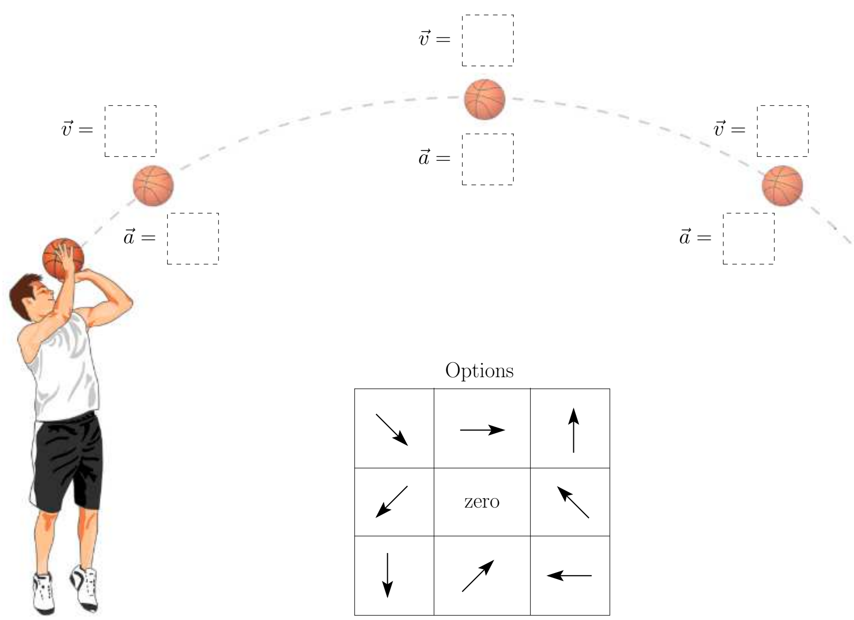
Ans: ______________________________

B) Alice is rushing to make her plane and runs up the stairs instead of the escalator which is filled with people blocking her way. The escalator is moving up at 5 m/s. Bob is one of the people standing on the escalator, and sees Alice run by at 3 m/s relative to him. How fast is Alice running up the stairs?

LO	S	U
6.1		
20.1		

Ans: ______________________________

C) A ball is thrown into the air and follows the parabolic path indicated by the dashed line. Choosing from the 9 possibilities shown, sketch the approximate directions of the velocity and acceleration of the ball at each of the three locations in the appropriate boxes. (Neglect air resistance.)



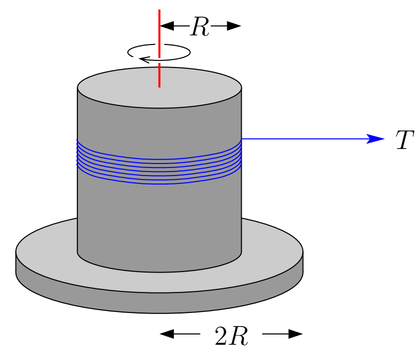
LO	S	U
13.1		
13.2		
13.3		
13.4		
13.5		
13.6		

D) A faulty spring does *not* obey Hooke's Law; instead the force is $F(x) = -kx - \beta x^2$ in the $\hat{\imath}$ direction when stretched or compressed a distance x from it's natural length. What is the potential energy, $U(x)$, for this faulty spring?

LO	S	U
8.1		
37.1		

Ans: ______________________________

E) A solid cylinder of mass M and radius R is glued to a 2^{nd} cylinder of mass M and radius $2R$. The object is fixed about a frictionless axis through its center and wound around many times with a light string as shown.



(i) What is the total moment of inertia of the half spool, in terms of M and R?

Ans: ______________________________

(ii) What is the angular speed of the object when its rotational kinetic energy is K? Your answer should be in terms of K, M and R.

Ans: ______________________________

(iii) When the string is pulled with a tension T:

(a) what is the magnitude of the torque it produces on the object?

Ans: ______________________________

(b) what is the instantaneous power supplied to the object by the string when it is rotating with an angular speed ω?

Ans: ______________________________

LO	S	U
51.1		
51.2		
53.1		
35.1		
54.1		
33.1		

F) A particle's position at $t = 0$ is $\vec{r}_0 = (2\hat{\imath} + 3\hat{\jmath})$ m. At $t = 2$ s it is at $\vec{r}_2 = (10\hat{\imath} + 9\hat{\jmath})$ m, and at $t = 5$ s it is at $\vec{r}_5 = (32\hat{\imath} + 43\hat{\jmath})$ m.

(i) Find the magnitude of the average velocity from $t = 0$ to $t = 2$ s.

Ans: ______________________________

(ii) Find the magnitude of the average velocity from $t = 0$ to $t = 5$ s.

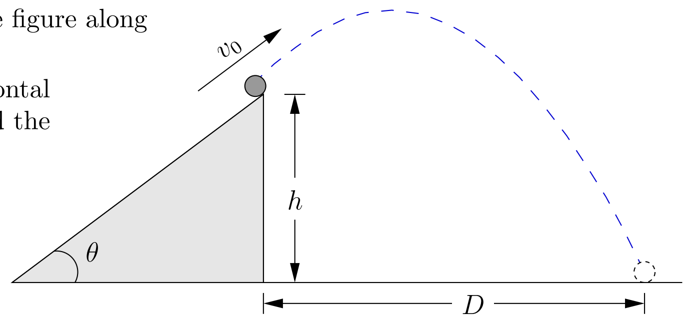
LO	S	U
2.1		
11.1		
11.2		
2.2		
11.3		
11.4		

Ans: ______________________________

Prob 1 A projectile is launched from a ramp with some unknown initial velocity $\vec{v}_0$ in a direction 36.9° above the horizontal as shown in the figure. In order to determine the initial velocity, you measure the distance from the ramp where it lands, and find $D = 1$ m. You also measure the height of the ramp to be $h = \frac{1}{2}$ m. As usual, assume air resistance is negligible, take $g = 10$ m/s^2 for the acceleration due to gravity in what follows, and consult the formula sheet for values of the trigonomentric functions of the angle.

(a) Pick your origin (where $x = y = 0$) and indicate it on the figure along with your positive directions for $\hat{\imath}$ and $\hat{\jmath}$.

(b) Use kinematics and the equation of motion in the horizontal direction to find an expression relating the speed, v_0, and the time it is in the air, t.



Ans: ______________________

(c) Next use your result to (b) and kinematics in the vertical direction to determine v_0 and t.

Ans: ______________________

LO	S	U
9.1		
9.2		
1.1		
14.1		
15.1		
1.2		
4.1		
5.1		
14.2		
15.2		

Prob 2 A 0.2 kg object on a frictionless horizontal surface is attached to the end of a horizontal spring that has a force constant $k = 3.2$ N/m. The spring is stretched 0.10 m from equilibrium and released from rest.

(a) What is the amplitude of the motion?

Ans: ______________________

(b) Use Newton's and Hooke's law to show that the acceleration of the object is negatively proportional to the displacement from equilibrium (*i.e.* $a = -\omega^2 x$) and from that determine the angular frequency, ω, for this system.

Ans: ______________________

(c) What is the frequency of the motion? (do *not* try to evaluate the value of π; leave it as a fraction).

Ans: ______________________

(d) What is the maximum speed of the object?

Ans: ______________________

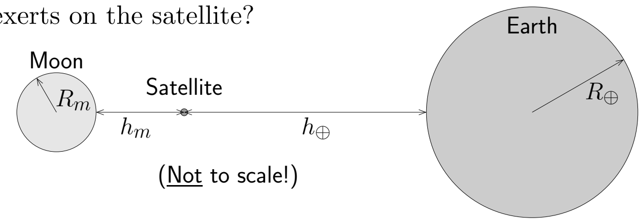
(e) What is the maximum acceleration of the object?

Ans: ______________________

LO	S	U
65.1		
21.1		
25.1		
65.2		
66.1		
65.3		
65.4		
65.5		

Prob 3 A $2,000$ kg satellite is directly between the Moon and the Earth. The mass and radius of the moon are $M_m = 8 \times 10^{22}$ kg and $R_m = 1,700$ km. The Earth is bigger with $M_\oplus = 6 \times 10^{24}$ kg and $R_\oplus = 6,400$ km. The satellite is at an altitude $h_m = 38,300$ km *from the surface* of the moon, and $h_\oplus = 393,600$ km *from the surface* of the Earth. In what follows, take the value of the universal gravitational constant to be $G = 7 \times 10^{-11}\ \mathrm{N\,m^2/kg^2}$.

(a) What is magnitude of the gravitational force that the moon exerts on the satellite?



Ans: ______________________________

(b) What is magnitude of the gravitational force that the satellite exerts on the moon?

Ans: ______________________________

(c) What is magnitude of the gravitational force that the Earth exerts on the satellite? (You may leave this expressed as a fraction of two integers).

Ans: ______________________________

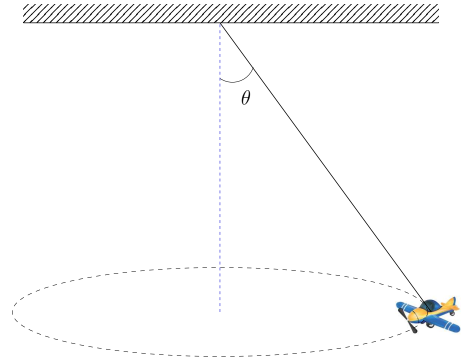
(d) What is magnitude of the gravitational force that the satellite exerts on the Earth?

Ans: ______________________________

(e) Neglecting any other astronomical objects (such as the Sun), what is the magnitude of the acceleration of the satellite? Here too you should express your answer as a fraction of two integers or, alternatively, to the first significant digit.

LO	S	U
10.1		
60.1		
60.2		
22.1		
10.2		
60.3		
60.4		
22.2		
21.2		

Ans: ______________________________



Prob 4 A 0.1 kg toy airplane is attached to the ceiling with a light string which has a length of 0.5 m. A child pushes the plane and starts it flying with a constant speed in a horizontal circle of radius 0.3 m. As usual, neglect air resistance and take $g = 10\ \mathrm{m/s^2}$.

(a) Turn the drawing into a free-body diagram for the airplane showing the forces acting on it. Clearly label each force in the diagram and indicate its direction.

(b) What is the angle, θ, that the string makes with respect to the vertical?

Ans: ______________________________

(c) What is the tension in the string?

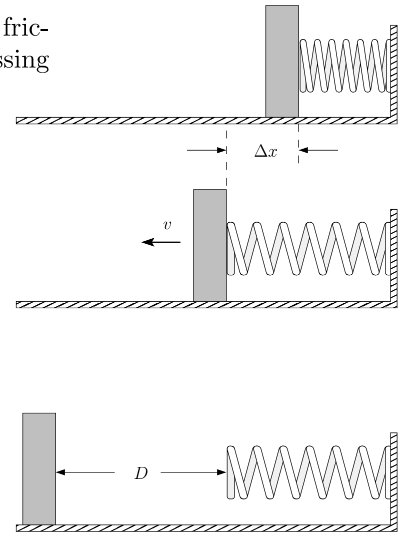
Ans: ______________________________

(d) What is the speed of the airplane?

Ans: ______________________________

LO	S	U
23.1		
24.1		
2.3		
3.2		
1.3		
21.3		
23.2		
24.2		
1.4		
16.1		
18.1		
19.1		
21.4		

Prob 5 A block of mass m is on a rough horizontal surface which has a coefficient of kinetic friction, μ_k. The block is pressed against a horizontal spring of force constant k, compressing the spring a distance Δx, and then released.



(a) How much energy does the work done by friction take away from the block as it moves Δx to the spring's natural length?

Ans: ______________________________

(b) How much work does the spring do on the block as it moves Δx to the spring's natural length?

Ans: ______________________________

(c) Use the work-energy theorem to find the speed, v, of the block when the spring reaches its natural length.

Ans: ______________________________

(d) Use energy conservation to find D, the maximum distance from the unstetched length that the block moves before coming to rest.

Ans: ______________________________

LO	S	U
21.5		
23.3		
26.1		
28.1		
32.2		
32.3		
38.1		
3.3		
34.1		
39.1		
6.2		
36.1		
40.1		
40.2		

Extra space:

Extra space (continued):