Printed Name: ______________________________

Section: ☐ 1 (8AM) ☐ 2 (9AM)

1	/ 15
2	/ 15
3	/ 15
4	/ 15
5	/ 12
6	/ 13
7	/ 15
8	/ 20
Total	**/120**

PHYSICS 221 FINAL EXAM

Do not open this booklet until instructed. The exam will end promptly at 4:00 PM.

Instructions: When you are told to begin, check that this examination booklet contains all the numbered pages from 2 through 9.

Read each problem carefully so that you are certain what it is asking. Do not panic or be discouraged if you cannot do every part of every problem. If a part of a problem depends on a previous answer you have not obtained, define a symbol for it and proceed to maximize your credit. Keep moving to finish as much as you can!

You must show your work. The purpose of this exam is to show how well you understood the material we have covered. You must include an adequate explanation, including correct equations where applicable, for full credit. A number with no explanation will not get credit. **Show your answer's units**, and give an adequate number of significant digits. Completely numerical solutions showing no equations are not eligible for partial credit. Do not use scratch paper. Indicate any work on the backs of the pages that you wish to be considered.

Box your answers.

This examination is administered under the Cadet Honor Code. All suspected violations must be reported appropriately. The seat next to you must be unoccupied. No talking is permitted during the examination, apart from questions to the instructor. You may use a scientific calculator, but may not use "advanced features", including graphing, solving, derivatives, integrals, symbolic manipulation, or equation storage capabilities. Any other electronic devices, including headphones, cell phones, PDAs, and MP3 players, may not be used during the exam in any way. You may use the equation sheet distributed with the exam. No other notes or textbooks may be open during the exam.

The content of this exam must be kept confidential until everyone has taken it.

Problem 1: [15pt]

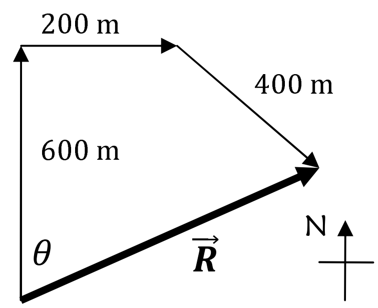
A helicopter takes off from the ground, and its height above the ground is given by $y = 0.40\, t^3$, where y is in meters and t is in seconds.

(a) [5pt] What is the speed of the helicopter as a function of a time? Give an equation for v as a function of t and a numerical factor. As in the above expression for the height, you don't have to show your units, but should assume v is in $\mathrm{m/s}$ and t is in seconds.

(b) [5pt] The helicopter releases a package at $t = 5.00\ \mathrm{s}$. At what speed does the package hit the ground, neglecting air resistance? [If you could not answer the previous question, assume the helicopter was moving upward at $20.0\ m/s$ at the instant when the package was released.]

(c) [5pt] If the package's mass is $10.0\ \mathrm{kg}$, how much work did the helicopter's engines have to do to lift the package to the point where it was released? [Assume the package was released with the same velocity that you used in part (b). It is not released at rest.]

Problem 2: [15pt] A boy runs across a field in three straight segments, in a total time of exactly 3 minutes. He first runs $600\ \mathrm{m}$ in due north. He then runs $200\ \mathrm{m}$ due east. He then runs $400\ \mathrm{m}$ south-east (a compass heading of 135° east of north). The times for these segments are $86.0\ \mathrm{s}$, $28.0\ \mathrm{s}$, and $66.0\ \mathrm{s}$, respectively.

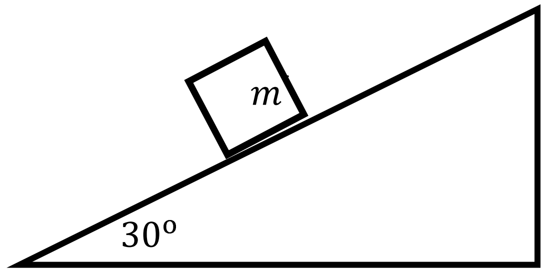


(a) [5pt] What was the boy's average speed for the entire race?

(b) **[5pt]** What are the magnitude and direction of the displacement vector $\vec{R}$ from his starting point to his ending point? Give the direction as a compass heading east of north (θ in the figure).

(c) **[5pt]** What are the magnitude and direction of the average velocity vector $\vec{v}_{\mathrm{avg}}$ for the entire three-segment run?

Problem 3: [15pt] A $3.00\ \mathrm{kg}$ block starts from rest at the top of a 30^{o} incline and slides a distance of $2.00\ \mathrm{m}$ down the incline in $1.50\ \mathrm{s}$. Do not neglect friction.

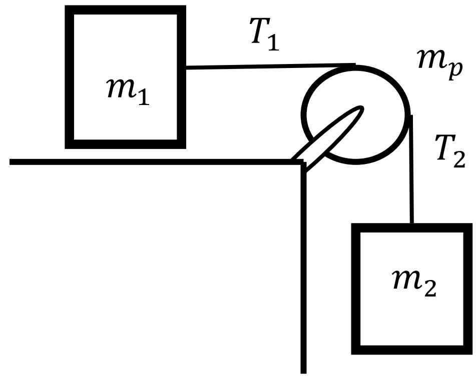


(a) [5pt] What is the magnitude of the block's acceleration?

(b) [5pt] What is the magnitude of the frictional force between the block and plane?

(c) [5pt] What is the coefficient of kinetic friction between the block and the plane?

Problem 4: [15pt]

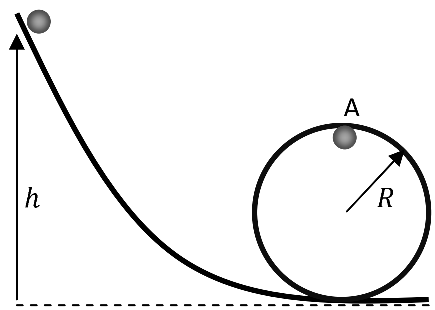


A object of mass $m_1 = 4.50$ kg placed on a horizontal table is connected to a light-weight string that passes over a pulley and then is fastened to a hanging object of mass $m_2 = 6.50$ kg, as shown in the figure. The pulley is a uniform cylinder of mass $m_p = 1.20$ kg and radius $r = 15.0$ cm. Neglect friction.

The moment of inertia of a uniform cylinder $is\ I = ½\, mr^2$.

Find the acceleration of the blocks and the tensions T_1, T_2 in the two parts of the string shown. [If you cannot solve the problem with $m_p \neq 0$, you may solve it with $m_p = 0$ for a maximum credit of 8 points.]

Problem 5: [12pt] A small bead **slides** without friction around a loop-the-loop track as shown in the figure, starting from rest at height h above the ground, and making a loop of radius R. Neglect the radius of the bead.



(a) [5pt] Find the speed of the bead at point A at the top of the loop in terms of h, R, and g.

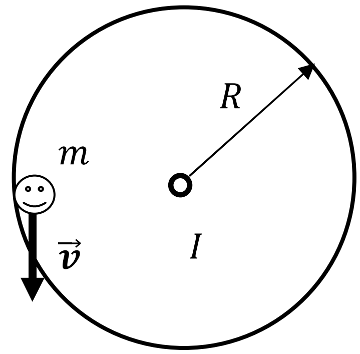
(b) [5pt] What is the minimum height h from which the bead can be released to remain in contact with the track at point A, thus making it around the loop without falling off? Express your answer in terms of R and a numerical constant.

(c) [2pt] If the bead rolls instead of sliding, how would the minimum height to make it around the loop compare to the answer to part (b)?

The new minimum height would be

☐ greater. ☐ less. ☐ the same.

Problem 6: [13pt] A woman of mass $m = 66.0$ kg stands at the rim of a horizontal turntable having a moment of inertia $I = 500$ $\mathrm{kg{\cdot}m^2}$ and a radius of $R = 2.00\ \mathrm{m}$. The turntable is initially at rest, and is free to rotate about a frictionless, vertical axle through its center. The woman then starts walking around the rim counterclockwise (as viewed from above the system) at a constant speed $v = 1.50\ \mathrm{m/s}$ relative to the ground.



(a) [3pt] Which of the following are conserved when the woman starts walking? Check all relevant boxes.

☐ Kinetic energy ☐ Linear momentum ☐ Angular momentum

(b) [5pt] At what angular speed does the turntable rotate while the woman is walking?

(c) [5pt] How much work must the woman do in the process of starting her walk and setting the turntable in motion at this constant speed?

Problem 7: [15pt] A block of mass $m_1 = 1.20\ \mathrm{kg}$ moving at $v_i = 2.5\ \mathrm{m/s}$ has an elastic collision with a block of mass $m_2 = 2.3\ \mathrm{kg}$ initially at rest. After the collision, both blocks are observed to move along the same line as the initial block's motion. [This is a one-dimensional collision.]

(a) [5pt] What was the velocity of the center of mass of the two blocks before and after the collision?

(b) [10pt] Find the final velocities v_1, v_2 of the two blocks after the collision. Include correct signs, consistent with the convention that the initial velocity of block 1 was positive. [This question is independent of part (a).]

Problem 8: [20pt] A $4.80\ \mathrm{kg}$ wooden cube measuring $20.0\ \mathrm{cm}$ on a side floats in water.

[The density of water is $1000\ \mathrm{kg/m^3}$.]

(a) [5pt] What is the vertical distance from the top of the water to the top of the floating cube?

(b) [5pt] How much force would you have to apply to the top of the cube so that it is just barely submerged, with the top of the cube at the surface of the water?

(c) [10pt] If you suddenly stop pushing down on the cube, it will bob up and down in the water. What is the period of the resulting harmonic motion? Neglect viscosity of the water.