Last Name (Please **print** in BLOCK LETTERS) **as on student card**	First Name(s) **as on student card**	Student Number	Practical Group Code

UNIVERSITY OF TORONTO
Faculty of Arts and Science

DECEMBER 2011 EXAMINATION – version 1
PHY 131H1F
Duration - 2 hours

PLEASE HAND IN

Aids allowed: A calculator without communication capability. Aid sheet: one single, original, handwritten 8 1/2 × 11 inch sheet of paper, which may be written on both sides.

Before starting, please **PRINT** your name, student number, and practical group code at the top of this page and on the answer sheet.

DO NOT separate the sheets of your question paper, except the final four pages for "Rough Work" which may be removed **gently**. Your paper should have 13 pages including 4 blank sheets at the end. If this is not the case, call an invigilator.

Answer Sheet:

1. **Use dark lead pencil.**
2. **Print** your name, practical group code, and student number at the top of the sheet. **Locate your exam version number in the header at the top of the cover page, and *fill in* the circle with the corresponding version number on your answer sheet. No crosses, circles or ticks!**
3. Mark in your student number by shading the circles.
4. Indicate the **most correct** answer to a multiple-choice question by filling the appropriate circle on the answer sheet and also by circling the corresponding answer on the exam paper.
5. If you wish to modify an answer, erase your pencil mark thoroughly. Do not use white-out.
6. **Do not write anything else on the answer sheet.** Use the back of the question sheets and either side of the blank sheets at the end for rough work.

The exam has 12 equally weighted multiple-choice questions, worth 60 marks in total, plus 2 problems, each worth 20 marks each for a fully correct, worked out solution.

Multiple-choice questions:
- Each correct answer is awarded 5 marks.
- Blank or incorrect answers are awarded zero marks.
- Multiple answers for a question are graded as a wrong answer.

Long-Answer Problems:
Maximum credit will be awarded only to fully worked solutions to all parts of the long problems. In addition to showing your work, please put your answer(s) for each part in the boxes provided. Please use the back-side of the sheets and both sides of the blank pages at the end for your rough work which will not be graded. Marks will be deducted for an incorrect number of significant figures in numerical answers.

	Marks
Problem 1	
Problem 2	
Total	

When the Chief Presiding Office declares the exam ended, stop writing immediately. Please put your answer sheet **inside your exam paper** and have the paper ready for an invigilator to pick up.

Good luck!

MULTIPLE CHOICE (60 marks total)

Possibly Helpful Equations and Constants

- Air resistance may be neglected in all problems unless otherwise stated.
- The acceleration due to gravity near the earth's surface is $g = 9.80$ m/s^2.
- The moment of inertia of a uniform cylinder or disk rotating about its centre is $\frac{1}{2}MR^2$.
- The moment of inertia of a uniform cylindrical hoop rotating about its centre is MR^2.
- An object that slides without friction down an inclined plane that makes an angle θ with the horizontal accelerates at $a_s = g \sin\theta$.
- The quadratic equation: If $ax^2 + bx + c = 0$, then $x = \dfrac{-b \pm \sqrt{b^2 - 4ac}}{2a}$
- Common Prefixes: k = "kilo-" = 10^3 c = "centi-" = 10^{-2} m = "milli-" = 10^{-3} μ = "micro-" = 10^{-6} n = "nano-" = 10^{-9}

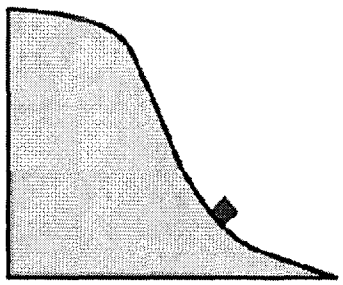
Question 1

A small scale is used to measure the individual mass of N different pieces of gravel. The estimated mean of the N measurements is 20 g and the uncertainty (*standard error of the mean*, $\sigma_m = \sigma/\sqrt{N}$) is 4 g. Next, the mass of a pile of the gravel is found to be 6000 ± 20 g. The best estimate of the number of pieces of gravel in the pile is:

A. 300 ± 1 B. 300 ± 5 C. 300 ± 24 D. 300 ± 60 E. 300 ± 80

Question 2

A cart slides without friction down a track as shown. As the cart slides beyond the point shown, what happens to its acceleration and its speed, both in the direction of its motion?



A. Both decrease.
B. The speed decreases, but the acceleration increases.
C. Both remain constant.
D. The speed increases, but the acceleration decreases.
E. Both increase.

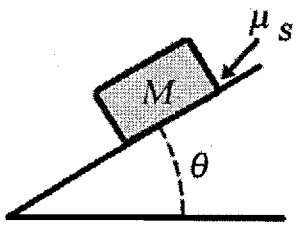
Question 3

Hanging from a spring scale in the elevator in the tower part of McLennan is a 0.750 kg mass. The spring scale measures the magnitude of the upward force on the mass. Define the $+y$-axis to be upwards. At a certain moment the elevator is traveling upward with $v_y = +3.5$ m/s and slowing down with $a_y = -1.5$ m/s^2. At that moment the reading of the spring scale, in N, is closest to:

A. 1.1 B. 2.6 C. 6.2 D. 8.5 E. 1.0×10^1

Question 4

A block of mass M is on an inclined plane making an angle θ with the horizontal. The coefficient of static friction between the block and the surface of the inclined plane is μ_s. The maximum angle θ for the block to not slip and begin sliding down the plane is:



A. 0 B. $\tan^{-1}(\mu_s)$ C. $\cos^{-1}(\mu_s)$
D. $\sin^{-1}(\mu_s)$ E. $\pi/2$

Question 5

A group of researchers make repeated measurements of the difference between the time for a neutrino to travel from Switzerland to Italy minus the expected time based on the speed of light. They observe a normal distribution of time difference measurements, with a mean of −60 ns and a statistical error in the mean of 6.9 ns. The number of measurements used in determining this mean was 16,111. According to this information, the standard deviation of their time difference measurements, in ns, is closest to:

A. 0.054 B. 0.47 C. 6.9 D. 880 E. 7600

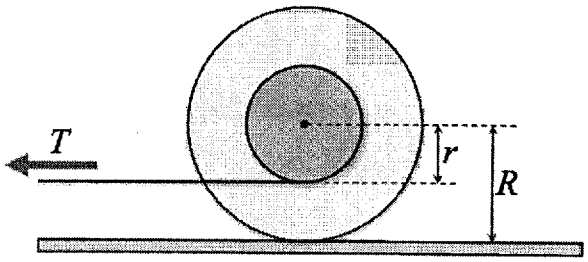
Question 6

A highway curve of radius 105 m is banked at a 23° angle with respect to the horizontal. If a car drives on this highway curve at a critical speed v_c, it can stay on the curve even if the road is completely frictionless. The critical speed v_c, in m/s, is closest to:

A. 21 B. 51 C. 49 D. 32
E. none of these; a car cannot stay on a curved frictionless road

Question 7

A yo-yo is pulled with a constant tension T. The string is horizontal and parallel to the table and unwinding from the bottom of the spool, as shown. The yo-yo's outer radius is R and the spool radius is r. The mass of the yo-yo is m and the moment of inertia of the yo-yo around the axis through its centre of mass is I. What is the angular acceleration of the yo-yo, assuming it rolls without slipping? Define clockwise angular acceleration to be negative, and counter-clockwise angular acceleration to be positive.



A. $-\frac{Tr}{I}$ B. $\frac{mgR-Tr}{I}$ C. $\frac{T(R-r)}{I+mR^2}$ D. $\frac{TR(R-r)}{I+mR^2}$ E. $\frac{TR(r-R)}{I+mR^2}$

Question 8

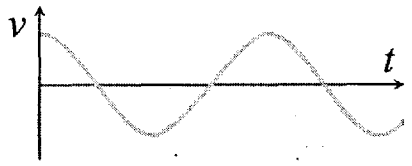
The engine in a sports car can provide a constant power. At full power, the car can accelerate from rest to speed v in time t. At this power, how long would it take for the car to accelerate from zero to $3v$?

A. $\sqrt{3}t$ B. $2t$ C. $3t$ D. $6t$ E. $9t$

Question 9
A vertical spring is known to stretch to 13 cm longer than its equilibrium length when pulled by a 250 N force. A fish hanging from the bottom of the spring oscillates vertically at a frequency of 2.3 Hz. The mass of the spring is negligible compared to that of the fish. The mass of the fish, in kg, is closest to:

A. 1.2 B. 3.3 C. 3.6 D. 9.2 E. 360

Question 10
An object of mass m is attached to a vertically oriented spring. The object is pulled a short distance below its equilibrium position and released from rest. Set the origin of the coordinate system at the equilibrium position of the object and choose upward as the positive direction. Assume air resistance and other dissipative forces are so small that they can be ignored. Beginning the instant the object is released, select the graph that best matches the velocity vs. time graph for the object.

A.


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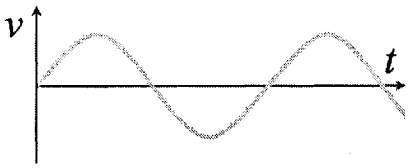
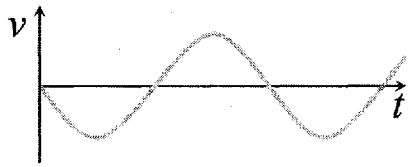
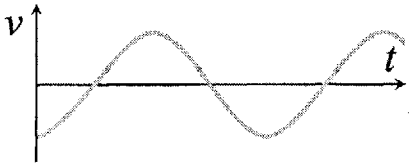
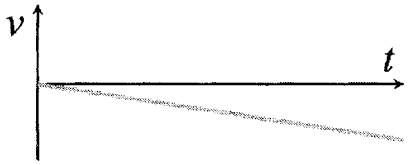
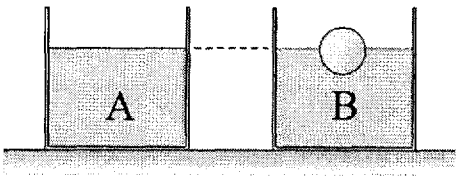


C.


D.


E.


Question 11
The two identical beakers shown are filled to the same height with water. Beaker B has a plastic sphere floating in it. Which of the following statements is correct?



A. Beaker A, with all its contents, weighs more than Beaker B with all its contents
B. Beaker A, with all its contents, weighs less than Beaker B with all its contents
C. Beaker A, with all its contents, weighs the same as Beaker B with all its contents
D. The weight of the water in Beaker B is larger than the weight of the water in Beaker A
E. Two identical beakers cannot be filled to the same height if a plastic sphere is floating in one of them.

Question 12
The aorta of your heart can be modeled as a tube of length 15 cm and inner radius 1.2 cm. The flow rate through the aorta for a resting person is 96 cm^3/s. The average speed, in cm/s, of blood flow through the aorta for a resting person is closest to:

A. 5.3 B. 21 C. 85 D. 96 E. 110

LONG ANSWER PROBLEM 1 (20 marks total)
There are three parts to this first Long-Answer Problem. Clearly show your reasoning as some part marks may be awarded. Write your final answers in the provided boxes.

Neglect air resistance in all parts. A tennis ball has a mass of 56.0 g, and a basketball has a mass of 0.560 kg (a basketball is ten times more massive than a tennis ball). All motion takes place along a vertical axis.

PART A (5 Marks)
A tennis ball is held directly above a basketball, very close but not quite touching. They are held above the ground so that the bottom of the basketball is 1.4 m above the ground. Simultaneously, they are both dropped from rest. What is the velocity of the basketball just before it hits the ground? Please write your answer clearly in the box below, including units, direction, and the correct number of significant figures.

PART B (5 Marks)
As the basketball and tennis ball fall, they continue to be very close without quite touching. The basketball collides elastically with the ground, bouncing straight back up again. During this collision the tennis ball is not affected. Just after the collision with the ground, what is the velocity of the basketball? Please write your answer clearly in the box below, including units, direction, and the correct number of significant figures.

PART C (10 Marks)

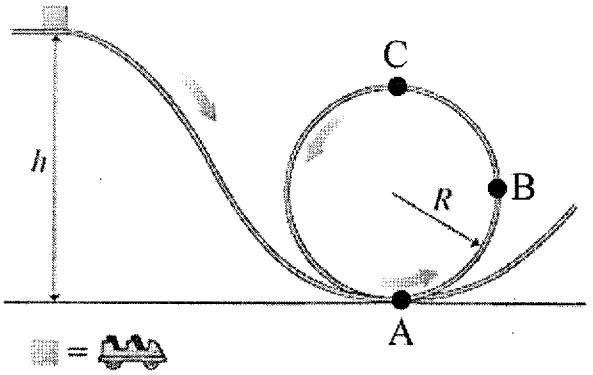
Just after the basketball collides with the ground, it collides elastically with the tennis ball. Just after this collision, what is the velocity of the tennis ball? Please write your answer clearly in the box below, including units, direction, and the correct number of significant figures.

LONG ANSWER PROBLEM 2 (20 marks total)

There are four parts to this second Long-Answer Problem. Clearly show your reasoning as some part marks may be awarded. Write your final answers in the provided boxes.

The following situation applies to parts A through D:

A roller coaster may be approximated by a block of mass m. The car, which starts from rest, is released at a height h above the ground and slides along a frictionless track. The car encounters a loop of radius R as shown. Assume that the initial height h is great enough so that the car never loses contact with the track. Assume air resistance is negligible. Assume that the acceleration due to gravity is constant and equal to g, which is not necessarily equal to 9.80 m/s^2.



Unless otherwise stated, answer all questions only in terms of the variables m, g, h, and R. Not all variables will appear in the answer to all parts.

PART A (4 Marks)

What is the speed v_A of the car at point A?

$v_A =$

PART B (4 Marks)

Write down the radial component of the velocity of the car at point B, $v_{r,B}$. Remember that the radial component points towards the centre of the loop.

$v_{r,B} =$

PART C (4 Marks)

Write down the tangential component of the acceleration of the car at point B, $a_{t,B}$. Remember that the tangential component is tangent to the loop and points in the direction of the motion of the car.

$a_{t,B} =$

PART D (8 Marks)

The vertical height from which the car began its journey is $h = 4R$. What is the magnitude of the normal force, $|\vec{n}| = n$, exerted on the car at point C? The variable h should not appear in your answer.

$n =$

ROUGH WORK (not marked)

ROUGH WORK (not marked)

ROUGH WORK (not marked)

ROUGH WORK (not marked)