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 2012 EXAMINATION – version 1
PHY 131H1F
Duration - 2 hours

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. A **paper** copy of an English translation dictionary.

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 12 pages including 3 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 at the top-right of the sheet, starting with a 0 if the first digit is a 9.
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.
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 Officer 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 a perpendicular axis through its centre is $\frac{1}{2}MR^2$.
- π = 3.14159 is the ratio of the circumference to the diameter of a circle.
- The quadratic equation: If $ax^2 + bx + c = 0$, then $x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$
- Common Prefixes: k = "kilo-" = 10^3 c = "centi-" = 10^{-2} m = "milli-" = 10^{-3} μ = "micro-" = 10^{-6} n = "nano-" = 10^{-9}

1. In a football play the stationary quarterback throws the ball with initial speed v_0 to a receiver who is running *straight towards him* with speed v_r. He throws the ball at an angle θ above the horizontal. Assume the ball is thrown and caught at the same height above the level playing field. At the moment the ball is thrown, the receiver is a distance D away from the quarterback. The time that the ball is in the air is t_c, and the acceleration due to gravity is g. What is the initial speed v_0 of the ball?

   (A) $\sqrt{\left(\frac{gt_c}{2}\right)^2 + \left(\frac{D}{t_c} - v_r\right)^2}$ (B) $\sqrt{(gt_c)^2 + \left(\frac{D}{t_c} - v_r\right)^2}$ (C) $\frac{D}{t_c}$

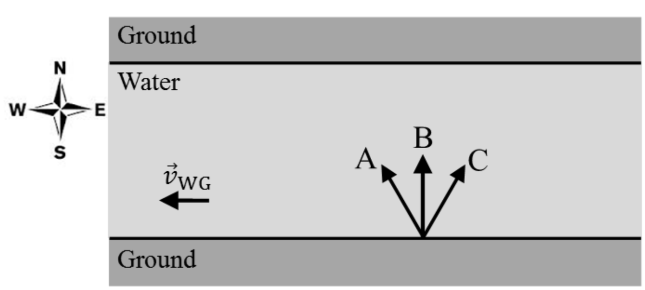
   (D) $\sqrt{\left(\frac{gt_c}{2}\right)^2 + \left(\frac{D}{t_c} + v_r\right)^2}$ (E) $\sqrt{(gt_c)^2 + \left(\frac{D}{t_c} + v_r\right)^2}$

2. You wish to estimate the volume of one of the Practicals rooms. You model the volume of the room as $l \times w \times h$, and estimate that the length of the room is $l = 20 \pm 2$ m, the width is $w = 7 \pm 1$ m, and the distance from the floor to the ceiling is $h = 3.5 \pm 0.5$ m. From these estimates, you conclude that the total volume of the room is 490 m^3. What is the error in this value?

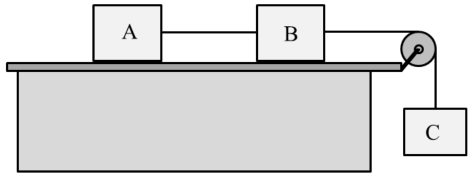
   (A) 110 m^3 (B) 20 m^3 (C) 2 m^3 (D) 0.2 m^3
   (E) An estimate cannot include an error.

3. A river runs from east to west. The velocity of the water relative to the ground has a constant value of $\vec{v}_{\text{WG}}$. A Swimmer can swim at some maximum constant speed relative to the water v_{SW}. The Swimmer chooses the direction of her velocity so she crosses the river from the south bank to the north bank in the minimum amount of time. Which of the three labeled arrows on the diagram best indicates the direction the swimmer chooses of her velocity relative to the water, $\vec{v}_{\text{SW}}$?

   (A) A. (B) B. (C) C.
   (D) While crossing the river, the direction of $\vec{v}_{\text{SW}}$ starts as C, but then curves toward B.
   (E) While crossing the river, the direction of $\vec{v}_{\text{SW}}$ starts as A, but then curves toward B.



4. Two blocks, A and B, of equal mass M, on a horizontal frictionless surface are connected by a horizontal massless string. Block B is connected by a second massless string to block C, also of mass M, which is hanging below a frictionless, massless pulley, as shown. What is the tension in the string which connects blocks A and B?

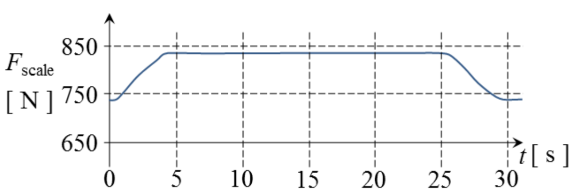


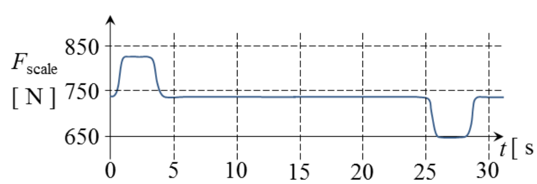
(A) $2Mg$ (B) Mg (C) $\frac{2Mg}{3}$ (D) $\frac{Mg}{2}$ (E) $\frac{Mg}{3}$

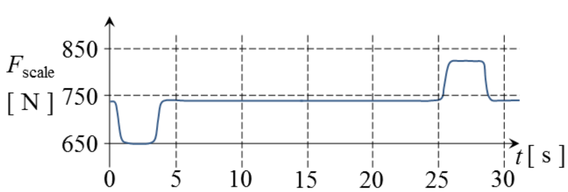
5. A 75 kg man jumps out of an airplane from a height of 9,144 m. As he falls, he may be modeled as a cylinder with drag coefficient $C = 1.1$ and cross-sectional area $A = 0.72\ \text{m}^2$. The air has a density of $1.2\ \text{kg/m}^3$. At the moment the man reaches terminal velocity, which of the following is the magnitude of the drag force due to the air on the man?

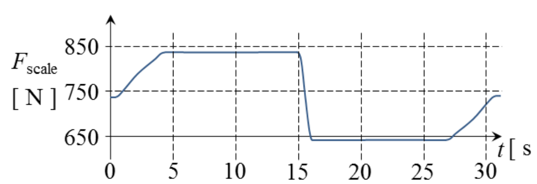
(A) 19 N (B) 370 N (C) 530 N (D) 740 N (E) 810 N

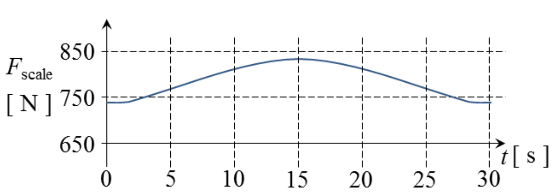
6. A person stands on a bathroom scale in an elevator on the ground floor of a tall building. The scale measures the upward normal force on the person, and reads 740 N when the elevator is stationary. The person presses the "14" button to go to the 14th floor, and the elevator travels there without stopping at any floors in between. The entire upward trip takes about 30 seconds, and for most of the trip the elevator is cruising at a constant velocity. Which of the graphs below best shows the magnitude of the force of the scale on the person over the 30 second upward trip?

(A)


(B)


(C)


(D)


(E)


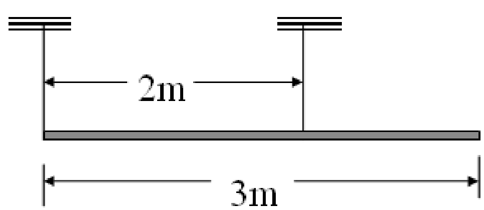
7. A car with mass 3.00×10^3 kg is traveling at an initial speed of 50.0 m/s when its brakes are applied, bringing it to a stop in 85.0 metres on a flat horizontal road. How much work does it take to stop the car?

(A) −7500 kJ (B) −5200 kJ (C) −3750 kJ (D) +3750 kJ (E) +5200 kJ

8. A stunt person jumps from the roof of a tall building, but no injury occurs because the person lands on a large air-filled bag. Which of the following best describes why no injury occurs?

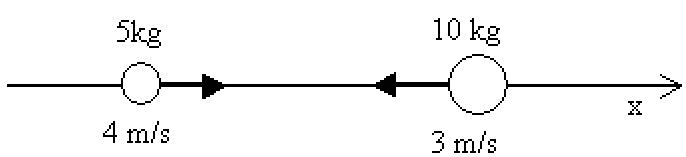
(A) The bag provides the necessary force to stop the person and reduces the change in momentum.
(B) The bag reduces the impulse to the person.
(C) The bag increases the amount of time the force acts on the person and reduces the change in momentum.
(D) The bag decreases the amount of time during which the momentum is changing and reduces the average force on the person.
(E) The bag increases the amount of time during which the momentum is changing and reduces the average force on the person.

9. A uniform beam of length 3.00 meters and mass 90.0 kg is supported by two ropes, as shown below, and is in static equilibrium. The right rope is attached to the top of the beam exactly 2.00 m from the left end of the beam. What is the tension in the left rope?



(A) 221 N (B) 250 N (C) 291 N (D) 314 N (E) 365 N

10. A 5 kg object moves to the right with an initial speed of 4 m/s and collides head-on with a 10 kg object, which is initially moving to the left with a speed of 3 m/s. The 10 kg object stops completely after the collision. You may assume that the only forces on the two objects are the forces they mutually exert on each other. With the positive direction to the right, the final velocity of the 5 kg object is:

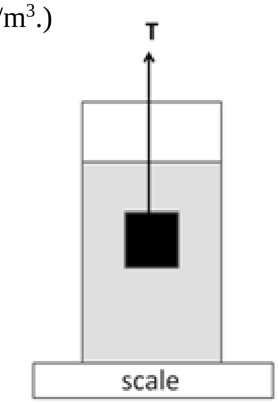


(A) −4 m/s (B) −3 m/s (C) −2 m/s (D) 6 m/s (E) 8 m/s

11. A block of mass *m* is hanging from a spring. When set in motion, the block undergoes vertical simple harmonic motion with a frequency *f*. When a second block is attached to the first block, the oscillation frequency changes to *f* /2. What is the mass of the 2nd block?

(A) *m* (B) *m*/2 (C) *m*/4 (D) 3*m* (E) 4*m*

12. A tank of water of total mass $m = 1.00 \times 10^2$ kg is placed on a scale. A block of steel hanging from a massless string is lowered into the water, but not touching the bottom of the tank; that is, the steel is completely immersed in the water, and the steel block is held motionless by the tension *T* of the string. The block of steel has a volume of 0.010 m^3. What is the reading of the scale as it supports the tank of water plus the steel hanging in the water? (The density of water is 1.000×10^3 kg/m^3, and the density of steel is 7750 kg/m^3.)



(A) 240 N (B) 650 N (C) 1100 N

(D) 2700 N (E) 3100 N

LONG ANSWER PROBLEM 1 (20 marks total)
There are 2 parts to this first Long-Answer Problem, each of which has two sub-parts. Clearly show your reasoning as some part marks may be awarded. Write your final answers in the provided boxes.

A car of total mass 1460 kg travels around a curve in a highway. The curve has a radius of 250 m. All motion takes place in a horizontal plane. The coefficients of static, kinetic and rolling friction between the rubber tires of the car and the concrete highway surface are $\mu_s = 1.00$, $\mu_k = 0.80$, and $\mu_r = 0.020$, respectively.

PART A
For this part, assume the curve is unbanked; the highway surface is flat and horizontal. Also assume the car is traveling at a speed of 30.0 m/s.

A.1 (5 Marks)
What is the magnitude of the force of rolling friction, f_r, on the car?

f_r =

A.2 (5 Marks)
What is the magnitude of the force of static friction, f_s, on the car?

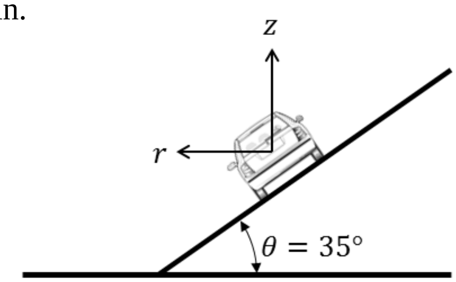
f_s =

PART B

For this part, assume the curve is banked at a 35° angle. Also assume the car is traveling at the maximum speed possible without slipping.

B.1 (3 Marks)

Please sketch a free-body diagram for the car in the box provided. Use the coordinate system provided, in which *z* is vertically upward, and *r* is toward the centre of curvature of the curve. Include and label all the forces acting on the car in the *r*-*z* plane, represented as a dot at the origin.



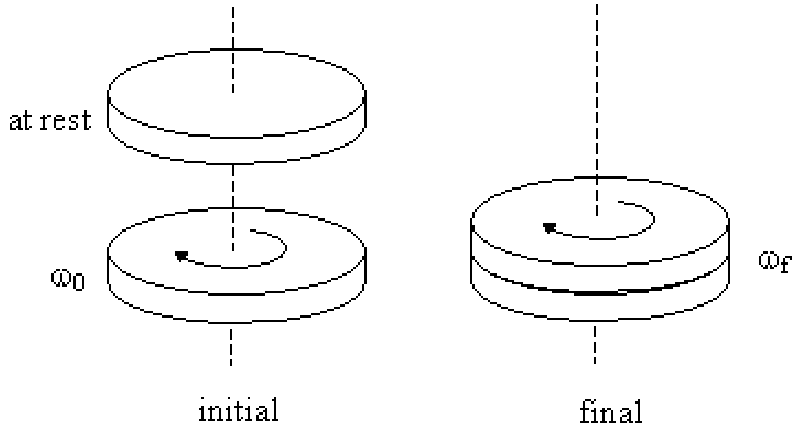
B.2 (7 Marks)

What is the maximum speed of the car so that it continues to roll without slipping?

$v_{\max} =$

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.

A system is composed of two identical uniform solid disks, each of mass 1.0 kg and radius 0.30 m. Initially, the bottom disk is rotating with angular velocity $\omega_0 = 3.0$ rad/s around a fixed frictionless axle, and the top disk is at rest. The top disk is now dropped onto the bottom one, and, due to the kinetic friction between the surfaces, eventually both disks rotate with the same final angular velocity ω_f (around the same axis). There is no net external torque acting on the two-disk system.



PART A [5 points]
What is the ratio of the final angular momentum of the system, L_F, to the initial angular momentum of the system, L_0? Explain your answer in a few words.

PART B [5 points]

Find ω_f?

$\omega_f =$

PART C [5 points]
What is the ratio of the final rotational kinetic energy of the system, K_f, to the initial rotational kinetic energy of the system, K_0?

$$\frac{K_f}{K_0} =$$

PART D [5 points]
What is the change in thermal energy of the system as the two disks come to reach the same final angular velocity?

$\Delta E_{th} =$

ROUGH WORK (not marked)

ROUGH WORK (not marked)

ROUGH WORK (not marked)