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

PLEASE HAND IN

UNIVERSITY OF TORONTO
Faculty of Arts and Science

APRIL/MAY 2011 EXAMINATION — version 1
PHY131H1S
Duration – 3 hours

Aids allowed: A pocket calculator with no communication ability. Up to two aid-sheets prepared by the student, no larger than 8.5"x11", each written on both sides.

- **Turn off** any communication device you may have and place it far from where you are sitting.
- **DO NOT separate the sheets of your question paper.** You can, however, "carefully" tear off the 3 blank pages at the end, as they do not have to be handed in.
- Before starting, please **PRINT IN BLOCK LETTERS your name, student number, and tutorial group code** at the top of this page **and** on the answer sheet.
- Check that the test-version numbers under the shaded circle at the top right of the answer sheet and in the title of your test paper match. If they do not, call an invigilator; if they do, **do not write anything on or near the circles.**

Scanned Area of the Answer Sheet:

1. **Use a dark-black, soft-lead pencil or a black pen.**
2. Mark in your student number by shading the circles in the student number area.
3. Indicate your answer to a multiple-choice question by **thoroughly** filling the appropriate circle on the answer sheet and also by recording your answer on the test paper.
4. If you wish to modify an answer, erase your pencil mark thoroughly, or use dry tape white-out sparingly.
5. **Do not write anything else on the answer sheet.** Use the blank sheets at the end or the back of the question sheets for rough work.

The test consists of **16** multiple-choice questions, worth 4 points each, or altogether 64 points. The test also has a set of free-form questions worth 36 points, for which fully worked solutions are required. The total possible number of points is 100.

Multiple-choice questions:

- Please choose the best answer.
- Blank or incorrect answers are worth zero points.
- Multiple answers for the same question result in zero points for that question.

Free-form Questions: To be awarded maximum credit, you must provide fully worked solutions to all parts of the free-form questions. In addition to showing your work, please put your answer(s) for each part in the boxes provided. You can use the back-side of the sheets and the blank pages at the end for your rough work which will not be graded or taken into account.

When the invigilators declare the test ended, **stop any writing or filling of circles** on the answer sheet immediately. Please put your answer sheet **inside your test paper** and have the paper ready for an invigilator to pick up.

Possibly helpful information for this test:

Acceleration due to gravity near the surface of the Earth: $g = 9.80\ \text{m/s}^2$

2π radians = 360° $\pi = 3.14159$

density of water $\rho = 1.00 \times 10^3\ \text{kg/m}^3$

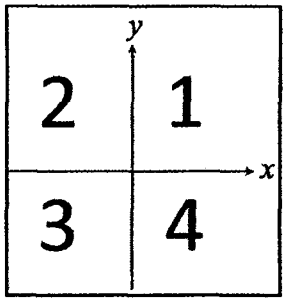
1 pound = 4.45 Newtons

Atmospheric pressure = 1.013×10^5 Pa

Coefficients of friction

Materials	Static μ_s	Kinetic μ_k	Rolling μ_r
Rubber on concrete	1.00	0.80	0.020
Wood on snow	0.12	0.060	

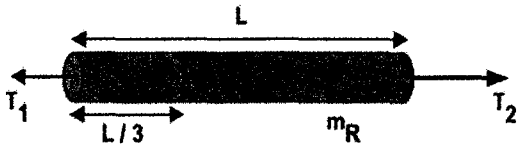
Quadrants:



The quadratic equation: If $ax^2 + bx + c = 0$, then $x = \dfrac{-b \pm \sqrt{b^2 - 4ac}}{2a}$

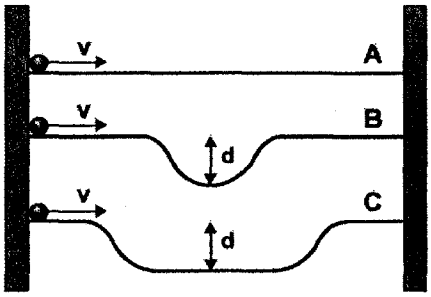
MULTIPLE CHOICE (64 points total)

1. A uniform rope of mass m_R and length L has 2 forces pulling it in opposite directions: T_2 and T_1, as shown. Assume the magnitude of T_2 is greater than the magnitude of T_1. Assume the sag of the rope is negligible. What is the tension in the rope at a distance $L/3$ from the left side?



   A. 0
   B. $T_2 - T_1$
   C. $(T_2 - T_1) / 3$
   D. $(T_2 + 2T_1) / 3$
   E. $3(T_2 + T_1)$

2. Three small balls A, B, and C are launched with equal speeds on three different tracks, as shown. Friction and air resistance are negligible. The times for the balls to reach the right side of their tracks are t_A, t_B and t_C respectively. Which answer gives the correct ranking of the three times?



   A. $t_A = t_B = t_C$
   B. $t_A > t_B = t_C$
   C. $t_A < t_B < t_C$
   D. $t_A < t_B = t_C$
   E. $t_A > t_B > t_C$

3. A ship is floating in a canal lock, which is only a little bit larger than the ship itself. The ship is loaded with steel ingots, which are large bars of steel. The crew becomes angry with the captain of the ship and throws the steel ingots overboard into the water of the lock. Due to this, what happens to the level of the water in the lock?

   A. It remains the same.
   B. It rises slightly.
   C. It lowers slightly.

4. On March 11, 2011 a large earthquake and tsunami occurred in Japan. Due to this, the rotation period of the Earth decreased by 1.6 microseconds. What was the most likely cause of this change in rotational period?

   A. The moment of inertia of the Earth increased slightly.
   B. The moment of inertia of the Earth decreased slightly.
   C. The tsunami exerted a torque on the earth which increased its angular speed.
   D. The tsunami exerted a torque on the earth which decreased its angular speed.
   E. The earthquake shook atomic clocks, causing them to speed up slightly.

5. In Practicals you caused a cart to roll down an inclined track at a constant velocity. As part of the experiment you measured the angle of the incline. Like a good experimentalist, you reported the angle of the incline as $\theta \pm \Delta\theta$, where θ is your value and $\Delta\theta$ is your error. This means
   A. the angle of the incline may either be $\theta + \Delta\theta$ or $\theta - \Delta\theta$.
   B. the angle of the incline must be between $\theta - \Delta\theta$ and $\theta + \Delta\theta$.
   C. there is about a 68% chance that the angle of the incline lies between $\theta - \Delta\theta$ and $\theta + \Delta\theta$.
   D. the angle of the incline is either θ or $\Delta\theta$, and there is a 50% chance of either possibility.
   E. that due to human error, no actual measurement of the angle of the incline is possible.

6. A simple pendulum consisting of a bob of mass m attached to a string of length L swings with a period T. If the pendulum is placed on the moon where the gravitational acceleration is about $g/6$, approximately what will its period now be? [Neglect air resistance in both cases.]
   A. T
   B. $T/\sqrt{6}$
   C. $\sqrt{6}\,T$
   D. $T/6$
   E. $6T$

7. Two forces, $\vec{F}_1$ and $\vec{F}_2$, act at a point. $\vec{F}_1$ has a magnitude of 9.80 N and is directed at an angle of 61.0° above the negative x-axis in the second quadrant. $\vec{F}_2$ has a magnitude of 6.20 N and is directed at an angle of 52.2° below the negative x-axis in the third quadrant. What is the y-component of the resultant force at the point?
   A. 0.951 N
   B. 3.67 N
   C. 4.77 N
   D. 8.55 N
   E. 13.5 N

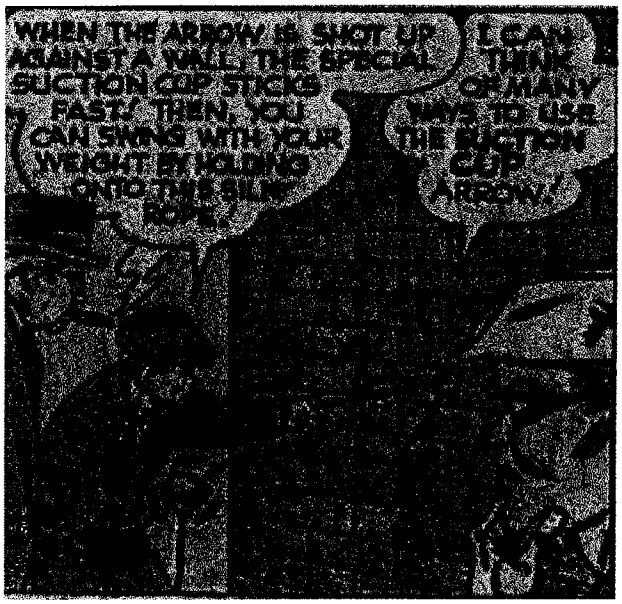
8. A turntable is rotating with an angular velocity of 1.7 rad/s, counter-clockwise, and is speeding up with an angular acceleration of 3.5 rad/s^2, also counter-clockwise. A penny sits on the turntable, a distance of 0.70 m away from the rotation axis. What is the magnitude of the acceleration of the penny?
   A. 2.0 m/s^2
   B. 2.5 m/s^2
   C. 3.2 m/s^2
   D. 4.5 m/s^2
   E. 9.8 m/s^2

9. A person who normally weighs 150 pounds is standing on a scale inside an elevator in the Physics building. While the elevator is moving upwards with a constant speed of 7.0 m/s, the reading of the scale is _____. While the elevator is moving upwards but slowing down at a rate of 4.9 m/s^2, the reading of the scale is _____. [The two blanks in this paragraph are best filled by which of the following two responses, separated by a comma?]
   A. 150 pounds , 75 pounds
   B. 150 pounds , 225 pounds
   C. greater than 150 pounds , 75 pounds
   D. greater than 150 pounds , between 75 and 150 pounds
   E. less than 150 pounds , greater than 75 pounds

10. A 0.013 kg bullet pierces a sand bag 32 cm thick. If the initial bullet speed was 68 m/s and it emerged from the sandbag with a speed of 18 m/s, what is the average magnitude of the friction force the bullet experienced while it traveled through the bag?
   A. 0.87 N
   B. 2.8 N
   C. 8.7 N
   D. 28 N
   E. 87 N

11. A motorcycle has a constant speed, v, as it passes over the top of a hill whose radius of curvature is R. The mass of the motorcycle and driver is m. What is the magnitude of the normal force that acts on the motorcycle?
   A. $m(g - v^2/R)$
   B. $m(g + v^2/R)$
   C. $m(v^2/R - g)$
   D. mg
   E. mv^2/R

12. The Green Arrow was a fictional comic book character who could use a suction-cup arrow connected to a silk rope to support his own weight. Assume the suction cup is circular, and that it forms a perfect vacuum with a perfect seal when it comes in contact with a flat, horizontal ceiling. What must be the minimum diameter of such a suction cup in order to support the 750 N weight of the Green Arrow? [NOTE: Do *not* trust that the apparent size of the suction cup as drawn in the comic to the right is to scale.]



A. 4.9 cm
B. 9.7 cm
C. 35 cm
D. 1.8 m
E. 3.5 m

13. A spring is standing upright on a table with its bottom end fastened to the table. A block, initially at rest, is dropped from a height h above the top of the spring. The block sticks to the top end of the spring and then oscillates with an amplitude of A. What is the angular frequency of vertical oscillations of the block, ω, in rad/s?

A. $\left[\dfrac{g}{\sqrt{h^2 + A^2} - h}\right]^{1/2}$

B. $\left[\dfrac{2g(A+h)}{A^2}\right]^{1/2}$

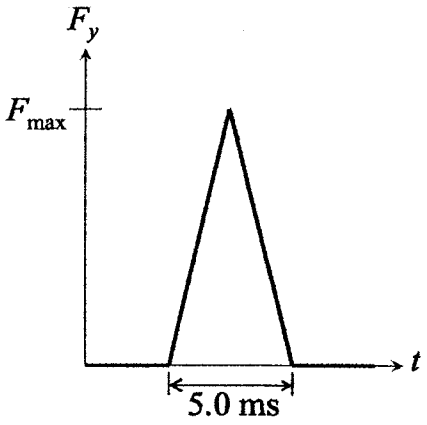
C. $\left[\dfrac{g}{\sqrt{h^2 - A^2} + h}\right]^{1/2}$

D. $\left[\dfrac{g}{2h - \sqrt{h^2 + A^2}}\right]^{1/2}$

E. $\left[\dfrac{gh}{h^2 + A^2}\right]^{1/2}$

14. A 1500 kg car with rubber wheels drives around a curved road of radius 75 m with a constant speed of 15 m/s. The road is horizontal, flat, and made of concrete. What is the size of the friction force on the car?
    A. 290 N
    B. 4500 N
    C. 4800 N
    D. 12,000 N
    E. 15,000 N

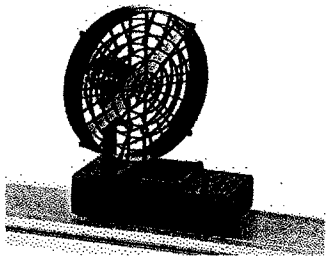
15. A 0.30 kg ball is dropped from a height of 2.0 m, bounces on a hard floor, and rebounds to a height of 1.2 m. The graph shows the vertical force of the floor on the ball as a function of time. What maximum force does the floor exert on the ball?
    A. 170 N
    B. 580 N
    C. 750 N
    D. 930 N
    E. 1300 N



16. A 50.0 kg sprinter, starting from rest, runs the 100.0 m dash in 13.4 seconds. Assume she has a constant acceleration. What is her average power output during the sprint?
    A. 4.16 W
    B. 104 W
    C. 208 W
    D. 416 W
    E. 5570 W

FREE-FORM IN FOUR UNRELATED PARTS (36 points total)
Clearly show your reasoning and work as some part marks may be awarded. Write your final answers in the boxes provided.

PART A



Imagine you have a cart on a track with a fan attached to it which causes it to accelerate along the track. You release the cart from rest and then use a digital stopwatch to measure the time it takes the cart to travel 1.75 m. You estimate the error in the distance you measured to be ±1.0 cm, so your measurement of the distance is 1.750 ± 0.010 m. You then repeat the time measurements for a total of 5 trials. The time measurements are shown in the Table.

Trial #	Time (s)
1	5.53
2	5.50
3	5.52
4	5.51
5	5.49

1. What is the best estimate for the mean time, t, including the error in this mean?

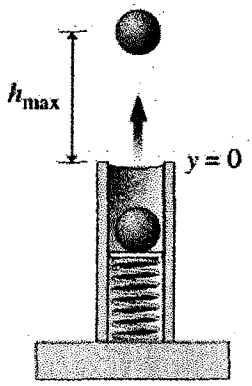
$t =$ ±

2. You model the distance as a function of time with the kinematic equation $d = \frac{1}{2} a t^2$. From your measurement of d and your best estimate for the mean time, t you wish to derive the acceleration, a, which is $a = 2d/t^2$. What is the best estimate for the acceleration, including the error in the acceleration?

$a =$ ±

PART B

A spring-loaded toy gun is used to shoot a ball of mass $m = 1.20$ kg straight up in the air, as shown in the figure. The spring has spring constant $k = 533$ N/m. If the spring is compressed a distance of 15.0 centimeters below its equilibrium position of $y = 0$ and then released, the ball reaches a maximum height $y = h_{max}$. There is no air resistance, and the ball never touches the inside of the gun. Assume that all movement occurs in a straight line up and down along the y-axis. What is h_{max}? [Please express your final answer in the box provided in m to 3 significant figures.]



$h_{max} =$

PART C

Winnipeg is 1,300 km east of Calgary. A plane leaves Calgary, flying with a speed, relative to the air, of 780 km/hr. There is an arctic wind blowing from north to south at 95 km/hr.

1. In which direction should the pilot fly the plane in order to be traveling east relative to the ground? [Please express your final answer in the box provided in degrees to 2 significant figures. Specify the direction as a number of degrees either "north of east" or "south of east".]

degrees_____of east.

2. Normally, the flight takes exactly 1 hour and 40 minutes. Due to the arctic wind, will the flight be early or delayed? (circle one)

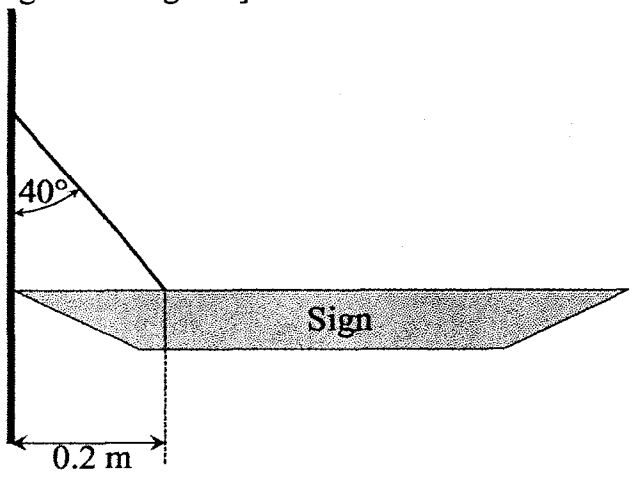
EARLY DELAYED

3. By how much time, Δt, will the flight be early or delayed due to the arctic wind? [Please express your final answer in the box provided in minutes to 2 significant figures.]

Δt =

PART D

A 0.80 m long sign extends from a wall supported by a rope as shown. The angle between the rope and the wall is 40.0°. If the sign has uniform density and does not slip, what is the minimum coefficient of static friction, $(\mu_s)_{min}$, between the sign and the wall? [Please express your final answer in the box to 2 significant figures.]



$(\mu_s)_{min}$ =

ROUGH WORK (not marked)