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

UNIVERSITY OF TORONTO
Faculty of Arts and Science
APRIL/MAY 2010 EXAMINATION — version 1
PHY131H1S
Duration – 3 hours

PLEASE HAND IN

PLEASE read carefully the following instructions.
Aids allowed: A non-programmable calculator without text storage. Up to two hand-written or typed aid-sheets prepared by the student, no larger than 8.5"x11", written on both sides.
Before starting, please **PRINT IN BLOCK LETTERS 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 three 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.
Scanned Area of the Answer Sheet:

1. **Use a dark-black, soft-lead pencil or a black pen.**
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 shade in the corresponding version number on your answer sheet. No crosses, circles or ticks!**
3. Mark in your student number by shading the circles in the student number area.
4. Indicate the **most correct** answer to a multiple-choice question by **thoroughly** filling the appropriate circle on the answer sheet and also by recording your answer on the examination paper.
5. If you wish to modify an answer, erase your pencil mark thoroughly, or use dry tape white-out sparingly.
6. **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 examination consists of **16** multiple-choice questions, worth 4 points each, or altogether 64 points. The examination 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:

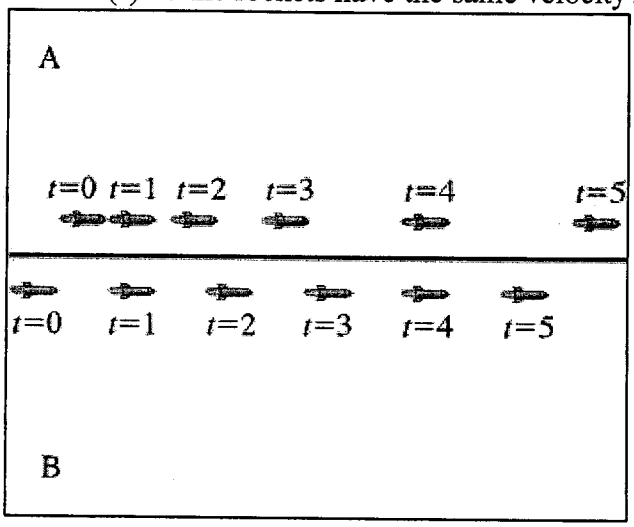
- Please choose the best answer.
- Blank or incorrect answers are worth zero points.
- Multiple answers for the same question result in zero points for that question.

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

Possibly helpful information for the 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 $\rho = 1.00 \times 10^3\ \text{kg/m}^3$
Coefficients of static and kinetic friction of wood on rubber: $\mu_s = 0.60$, $\mu_k = 0.25$.
Moment of Inertia of thin rod with axis about end: $\frac{1}{3}ML^2$

MULTIPLE CHOICE (64 points total)

1. Two toy rockets are traveling in the same direction. A diagram is shown of a time-exposure image where a stroboscope has illuminated the rockets at the uniform time intervals indicated. Both rockets move smoothly in the same direction. At what time(s) do the rockets have the same velocity?
   A. at time $t = 1$ only
   B. at time $t = 4$ only
   C. at times $t = 1$ and $t = 4$ only
   D. at some instant in time between $t = 1$ and $t = 4$
   E. at no time shown in this figure



2. Two identical stones are dropped from a tall building, one after another. Both balls are initially released from rest. Assume air resistance is negligible. While both stones are falling, what will happen to the vertical distance between them?
   A. It will increase.
   B. It will decrease.
   C. It will remain constant.
   D. It will first increase, then remain constant.
   E. It will first decrease, then remain constant.

3. The captain of a plane wishes to proceed due West, relative to the ground. The speed of the plane is 245 m/s relative to the air. A weather report indicates that a 23.8 m/s wind is blowing from the South to the North. In what direction should the pilot head the plane relative to the air?
   A. 5.45° South of West
   B. 5.55° South of West
   C. 5.55° North of West
   D. 5.57° South of West
   E. 5.57° North of West

4. A student uses a digital angle gauge to measure the slope of a ramp when a shoe on the ramp begins to slip. The angle is measured 5 times, and the measurements reported are 35.4°, 34.8°, 35.2°, 35.6°, and 35.0°, all measured above the horizontal. The estimated mean of these five measurements is 35.2°. What is the estimated standard deviation of the five measurements?
   A. 0.005°
   B. 0.03°
   C. 0.04°
   D. 0.08°
   E. 0.14°

5. Bin and Tania throw identical rocks off a tall building at the same time. Bin throws his rock straight downward. Tania throws her rock downward and outward such that the angle between the initial velocity of the rock and the horizontal is 30 degrees. Tania throws the rock with a speed twice that of Bin's rock. Which rock hits the ground first (assuming the ground near the building is flat)?
   A. They hit at the same time
   B. Bin's rock
   C. Tania's rock

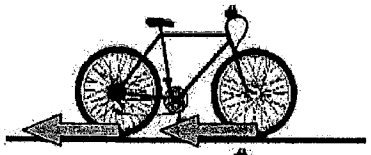
6. A tetherball is a rubber ball suspended by a string, the other end of which is attached to the top of a stationary metal pole. The tetherball travels in a horizontal circle at a constant speed. As the tetherball travels, it has
   A. constant velocity and constant acceleration.
   B. constant velocity and changing acceleration.
   C. changing velocity and changing acceleration.
   D. changing velocity and constant acceleration.

7. A tetherball is a rubber ball suspended by a 2.4 m long string, the other end of which is attached to the top of a 3.0 m high stationary metal pole. While the tetherball travels in a horizontal circle at a constant speed, the string makes a constant angle of 42° with the pole. What is the speed of the ball?
   A. 3.8 m/s
   B. 4.0 m/s
   C. 4.2 m/s
   D. 4.6 m/s
   E. 4.8 m/s

8. An object accelerates at 4.1 m/s^2 when pulled in the same direction by two identical rubber bands. What will be the object's acceleration if it is pulled in the same direction by four of these rubber bands?
   A. 2.0 m/s^2
   B. 2.1 m/s^2
   C. 4.1 m/s^2
   D. 8.2 m/s^2
   E. 16 m/s^2

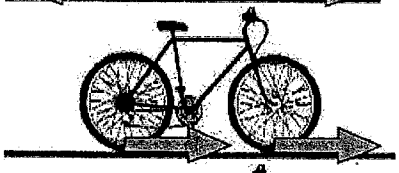
9. Consider a bicycle whose velocity is to the right, and is speeding up. It is speeding up because the rider is pedaling, which drives the back wheel. The front wheel rotates on a frictionless axle. Both wheels roll without slipping on the ground. Which diagram below correctly shows arrows corresponding to the direction of static friction of the road acting upon the bottoms of the two wheels?

A.

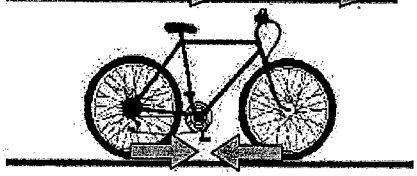


B.

C.

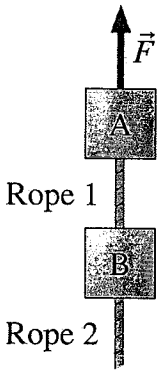


D.



10. Two blocks, labeled A and B, are connected by a rope, as shown. A second rope hangs beneath the lower block. Block A has a mass of 1.0 kg, and Block B has a mass of 2.0 kg, and each rope has a mass of 0.250 kg. The entire assembly is accelerated upward at 2.0 m/s^2 by force F. What is the tension at the bottom end of rope 1?

A. 15 N
B. 21 N
C. 24 N
D. 27 N
E. 41 N

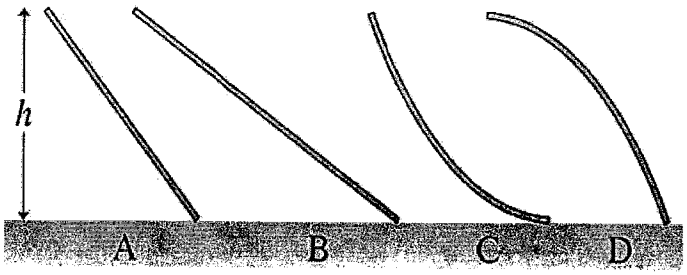


11. An object at rest on a flat, horizontal surface explodes into two fragments, one 4 times more massive than the other. Each fragment slides with the same coefficient of static friction between itself and the surface. The heavier fragment slides a distance, d, before stopping. How far does the lighter fragment slide?

A. $2d$
B. $4d$
C. $6d$
D. $8d$
E. $16d$

12. A small child slides down the four frictionless slides A–D. Each has the same height, h, and the child always starts from rest. Rank in order, from largest to smallest, her speeds v_A to v_D at the bottom.

A. $v_C > v_A = v_B > v_D$
B. $v_C > v_B > v_A > v_D$
C. $v_D > v_A > v_B > v_C$
D. $v_A = v_B = v_C = v_D$
E. $v_D > v_A = v_B > v_C$

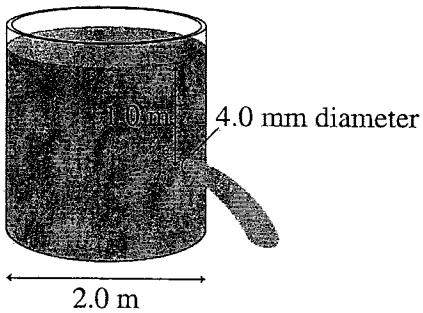


13. The engine in a 1400 kg car has a maximum power output of 45 kW, but 35% of the power is lost before reaching the drive wheels. The coefficient of rolling friction between the wheels and the road is 0.03. Neglect air resistance. What is the car's top speed?
A. 0.11 m/s
B. 2.1 m/s
C. 56 m/s
D. 71 m/s
E. 110 m/s

14. Objects of equal mass are oscillating up and down in simple harmonic motion on two different vertical springs. The spring constant of spring 1 is k_1. The motion of the object on spring 1 has twice the amplitude as the motion of the object on spring 2. The magnitude of the maximum velocity is the same in each case. What is the spring constant of spring 2?
A. k_1
B. $\sqrt{2}\,k_1$
C. $2k_1$
D. $4k_1$
E. $8k_1$

15. The pressure at 10 m below the surface of the ocean is about 2.00×10^5 Pa. Now consider the pressure at 20 m below the surface of the ocean. This pressure is
A. twice that at a depth of 10 m.
B. the same as that at a depth of 10 m.
C. half that at a depth of 10 m.
D. equal to that at a depth of 10 m plus the weight of a column of seawater 1 m^2 in cross section and 10 m high.
E. equal to the weight of a column of seawater 1 m^2 in cross section and 20 m high

16. A 4.0 mm diameter hole is 1.0 m below the surface of a 2.0 m diameter tank of water. What is the volume flow rate through the hole, in m^3/s?
A. 1.8×10^{-5}
B. 5.6×10^{-5}
C. 3.3×10^{-4}
D. 4.4×10^{-4}
E. 2.8×10^{-2}



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 (9 points)

An object of mass m is traveling on a horizontal surface. There is a coefficient of kinetic friction μ between the object and the surface. The object has speed v when it reaches $x = 0$ and encounters a spring, the other end of which is attached to a fixed wall. The object compresses the spring, stops, and then recoils and travels in the opposite direction. When the object reaches $x = 0$ on its return trip, it stops. Find k, the spring constant. [Please express k in terms of μ, m, g and v, and write your final answer in the box provided.]

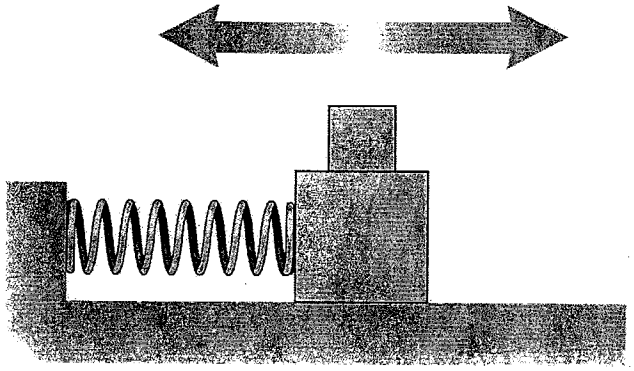
$k =$

PART B (9 points)
A wooden crate in a factory is dropped from a short height onto a conveyer belt. The conveyer belt is a long rubber surface that always moves at a constant horizontal speed of 1.2 m/s. When the crate hits the conveyer belt its initial horizontal speed is zero. How far is the crate dragged horizontally before it comes to rest relative to the conveyer belt? [Please express your answer in m, and write your final answer in the box provided.]

distance =

PART C (9 points)

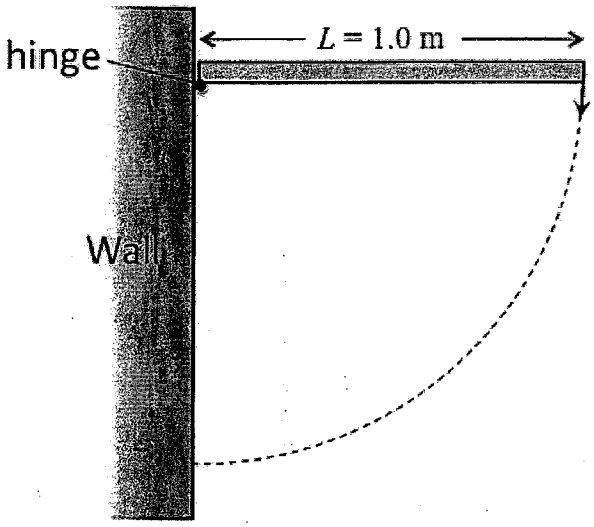
A 2.0 kg block rides on top of a 6.0 kg block as it oscillates on a frictionless surface, as shown. The spring constant is 25 N/m, and the coefficient of static friction between the two blocks is 0.60. What is the maximum oscillation amplitude for which the upper block does not slip. [Please express your answer in m, and write your final answer in the box provided.]



Amplitude =

PART D (9 points)

A 1.0 m long, 250 g rod is hinged at one end and connected to a wall. The hinge is frictionless. The rod is held out horizontally, and then released. What is the speed of the tip of the rod as it hits the wall? [Please express your answer in m/s, and write your final answer in the box provided.]



v_{tip} =

ROUGH WORK (not marked)

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