LAST NAME **as on student card**	First Name(s) **as on student card**	Student Number	Practical Group Code

PHY131H1F
Term Test 2 —version A
Tuesday, November 17, 2015
Duration: 80 minutes

Aids allowed: A calculator with no communication ability (programmable calculators and graphing calculators are okay). A single hand-written aid-sheet prepared by the student, no larger than 8.5"x11", written on both sides. A hard-copy English translation dictionary. A ruler.

- **Completely turn off** any communication device you may have and leave it with your belongings at the front of the room.

- **DO NOT separate the sheets of your question paper.** You can, however, *carefully* tear off the blank page at the end, as it does not have to be handed in.

- 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.

Locate your test version number in the header at the top of the page and fill in the circle with the corresponding version code on your answer sheet in the "Form Code" box. 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. It is not required to bubble in your surname on the lower half of the sheet.

Scanned Area of the Answer Sheet:

1. **Use a dark-black, soft-lead pencil or a black pen.**
2. 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.
3. If you wish to modify an answer, erase your pencil mark thoroughly.
4. **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 first part of the test consists of **10** multiple-choice questions, worth 2 points each, or altogether 20 points. Each multiple-choice question has one best answer, and up to four answers that are not the best. You receive 2 points for choosing the best answer and nothing else. You receive 0 points if you either choose a non-best answer, multiple answers, or no answer at all.

The second part of the test is a set of free-form questions, worth a total of 12 points. 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.

The total number of points available for the test is 32.

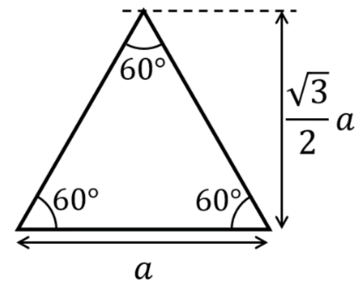
Possibly helpful information for this test:
π = 3.14159 is the ratio of the circumference to the diameter of a circle
g = 9.80 m/s^2 is the acceleration due to gravity near the Earth's surface.
$G = 6.67 \times 10^{-11}$ N m^2/kg^2 is the universal gravitational constant.

Common Prefixes:
k = "kilo-" = 10^3 c = "centi-" = 10^{-2} m = "milli-" = 10^{-3} μ = "micro-" = 10^{-6}
n = "nano-" = 10^{-9}

60 seconds = 1 minute; 60 minutes = 1 hour; 24 hours = 1 day; 365.25 days = 1 year

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

If the base of an equilateral triangle is a, then its height is $\frac{\sqrt{3}}{2}a$.



Air resistance may be neglected in all questions, unless otherwise stated.

MULTIPLE CHOICE PART (20 points total)
Choose the best answer for each question. 2 points per question, no penalty for guessing.

Question 1
A banked turn has a radius of 400 m and is designed for cars traveling at 90 km/hr. This means cars traveling at 90 km/hr can stay on the curve without assistance from friction. What is the banking angle of this curve?

(A) 9° (B) 10° (C) 13° (D) 17° (E) 64°

Question 2
You measure the mass of a cart to be (500 ± 5) g, and its speed to be (3.5 ± 0.7) m/s. What is its kinetic energy?

(A) 3 ± 2 J (B) 3.1 ± 0.7 J (C) 3.1 ± 1.2 J (D) 3.06 ± 0.30 J (E) 3.06 ± 0.61 J

Question 3
Here is a table of the results of four repeated measurements of x in m. Which of the choices below shows the best way to report the mean value of x based on these four measurements?

x_1	9.571
x_2	9.396
x_3	10.050
x_4	9.503

(A) 9.63 ± 0.14 m (B) 9.62983892 ± 0.28898099 m (C) 9.63 ± 0.29 m
(D) 9.63 ± 0.54 m (E) 9.6 ± 1.1 m

Question 4
Initially, Block 1 with mass m_1= 1 kg is moving on a frictionless table with velocity v_{1i} = +1 m/s along the x-axis and block 2 with mass m_2 = 0.5 kg is at rest. Block 1 collides elastically with block 2. The collision is head-on, so that all motion remains along the x-axis. What is the velocity of Block 1 after the collision?

(A) −0.7 m/s (B) −0.3 m/s (C) +0.3 m/s (D) +0.7 m/s (E) +1.3 m/s

Question 5
An energy-efficient refrigerator uses 250 W of power when it is running, and, due to good insulation, it only runs 15% of the time. An older refrigerator uses 400 W of power when it is running, and runs 20% of the time. If the cost of electricity is $0.12/kWh, how much money do you save over 30 days by using the energy-efficient refrigerator instead of the older one?

(A) Less than $0.01 (B) $3.24 (C) $3.67 (D) $6.91 (E) $300

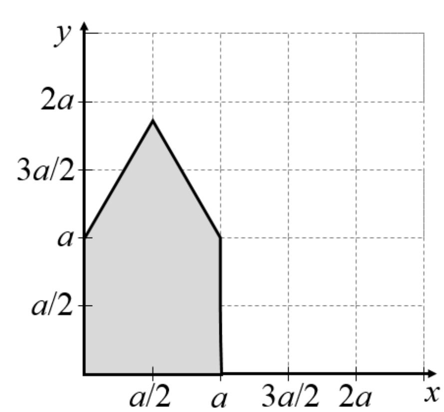
Question 6
Consider a mechanical spring that does not obey Hooke's Law. The spring is initially unstretched, with the unconstrained end of the spring at position $x = 0$. This particular spring provides a force $F = -k_2 x^2$. The nonlinear spring constant is $k_2 = 10^4$ N/m^2. The spring is now compressed so that the unconstrained end moves from $x = 0$ to $x = 0.10$ m. What is the work done by the spring as it is compressed?

(A) −0.63 J (B) −2.5 J (C) −2.9 J (D) −3.3 J (E) −3.5 J

Question7
A satellite in an elliptical orbit has a height above the surface of the Earth which ranges from 630 km at its lowest point, up to 7600 km at its highest. When it is at its lowest point (closest to the surface of the Earth), it's moving at 8.7 km/s. How fast is it moving at its highest point? [Assume the Earth is a sphere of radius 6370 km and mass 5.97×10^{24} kg.]

(A) 2.2 km/s (B) 4.4 km/s (C) 6.2 km/s (D) 8.7 km/s (E) 17 km/s

Question 8
A flat cookie has an even thickness, and is house-shaped, as shown. It is made of a square of side length a, connected underneath an equilateral triangle of side length a (the roof). The house sits so its bottom left corner is at the origin $[x, y] = [0,0]$, as shown. The peak of the roof is at $[x, y] = \left[\frac{a}{2}, \left(1 + \frac{\sqrt{3}}{2}\right) a\right]$. The x-coordinate of the center of mass is $x_{cm} = \frac{a}{2}$. What is the y-coordinate of the center of mass?



(A) 0.5 a (B) 0.74 a (C) 0.84 a
(D) a (E) 1.29 a

Question 9
A system consists of a car with momentum 25,000 kg m/s, South, and a truck with momentum 100,000 kg m/s, North. They have a head on collision and stick together. Which statement correctly describes the system immediately after the collision?

(A) The total kinetic energy of the system is converted to thermal energy.
(B) The total mechanical energy of the system is converted to thermal energy.
(C) The total kinetic energy of the system is conserved.
(D) The total mechanical energy of the system is conserved.
(E) Part of the kinetic energy of the system is converted to thermal energy.

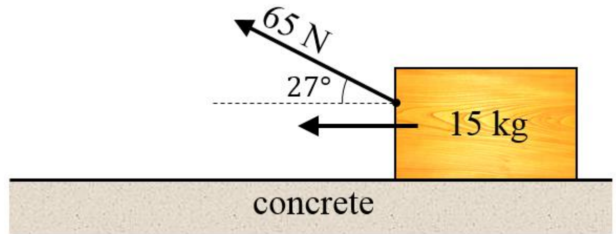
Question 10
A wheel with rotational inertia $I = 1.0$ kg m^2 is acted upon by a counterclockwise torque of constant magnitude 1.0 N m. The wheel starts from rest and the torque is applied for 3.0 seconds. What angle, in radians, has it turned through in this time?

(A) 1.5 (B) 3 (C) 4.5 (D) 9 (E) 18

FREE-FORM PART (12 points total)
For full marks, you must clearly show all of your work and reasoning in the space provided. State any assumptions you make, and show all the steps of your calculations. Write your final answers in the boxes provided.
For both problems in the free-form part, assume:

The coefficient of **kinetic** friction between wood and concrete is $\mu_k = 0.15$.
The coefficient of **static** friction between wood and concrete is $\mu_s = 0.30$.

Problem A
A wooden box of mass 15 kg is pulled to the left by a constant tension force of 65 N at an angle of 27° above the horizontal. It starts from rest and slides forward along a smooth, flat, horizontal concrete floor.



1. **(4 points)** How much time does it take the box to get up to a speed of 3.0 m/s?

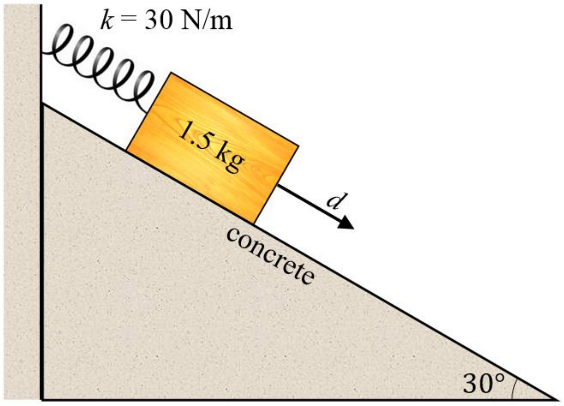
$t =$

2. **(2 points)** How much thermal energy is generated by friction during this time?

$E_{th} =$

Problem B (6 points)

1. **(5 points)** An unstretched spring is attached to a 1.5 kg wooden block on a concrete ramp which makes an angle of 30° with respect to the horizontal. The other end of the spring is fixed. The mass is released and it slides down the ramp and stretches the spring. The spring has a constant of 30 N/m. Find the maximum distance that the block slides down the ramp.



d_{max} =

2. **(1 point)** When the block gets to this position, does it stay still, or will it start back up the ramp? (Circle one)

STAY STILL START BACK UP

ROUGH WORK (not marked)