$\begin{array}{lcc}\begin{array}{l}\text { Given Name(s) } \\ \text { as on student card }\end{array} & \text { Student Number } & \begin{array}{c}\text { Tutorial Group } \\ \text { Code }\end{array}\end{array}$

## PHY131H1S

Test 1 -version 1
Tuesday, February 2, 2010
Duration: 80 minutes

## PLEASE read carefully the following instructions.

Aids allowed: A pocket calculator with no communication ability. A single aid-sheet prepared by the student, no larger than 8.5 " $\times 11$ ", 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 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 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 $\mathbf{8}$ multiple-choice questions, worth 2 points each, or altogether 16 points. The test also has a set of free-form questions worth 12 points, for which fully worked solutions are required. The total possible number of points is 28 .

## 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 the test:

$\pi=3.14159 \quad \pi$ radians $=180^{\circ}$
acceleration due to gravity near the Earth's surface is: $\vec{g}=9.8 \mathrm{~m} / \mathrm{s}^{2}$, down.
The quadratic equation: If $a x^{2}+b x+c=0$, then $x=\frac{-b \pm \sqrt{b^{2}-4 a c}}{2 a}$
Air resistance may be neglected in all questions.

## MULTIPLE CHOICE (16 points total)

1. The plot below shows the position of an object as a function of time. The letters H-L represent particular moments of time. At which moment in time is the speed of the object equal to zero?
A. H
B. I
C. J
D. K
E. L

2. A hockey-ball is thrown vertically upward and then comes back down. During the ball's flight up and down, its velocity and acceleration vectors are
A. always in opposite directions.
B. always in the same direction.
C. first in opposite directions and then in the same direction.
D. first in the same direction and then in opposite directions.
3. You want to swim straight across a river that is 66 m wide. You find that you can do this if you swim at $\theta=18^{\circ}$ upstream at a constant velocity of $1.5 \mathrm{~m} / \mathrm{s}$ relative to the water. The angle is measured from the line that is perpendicular to the river bank (directly upstream is $\theta=90^{\circ}$ and directly across the river is $\theta=0^{\circ}$ ). At what speed does the river flow?
A. $0.14 \mathrm{~m} / \mathrm{s}$
B. $0.46 \mathrm{~m} / \mathrm{s}$
C. $1.1 \mathrm{~m} / \mathrm{s}$
D. $1.4 \mathrm{~m} / \mathrm{s}$
E. $14 \mathrm{~m} / \mathrm{s}$
4. You measure the distance between two trees to be $54.0 \pm 0.5 \mathrm{~m}$. Your friend, Bob, runs as fast as he can from the first tree to the second tree, touches it, and then runs all the way back to the first tree. You measure the time for his trip there and back to be $17.0 \pm 0.2 \mathrm{~s}$. Which of the following is a good estimate for Bob's average running speed over these 17 seconds?
A. $6.35 \pm 0.048 \mathrm{~m} / \mathrm{s}$
B. $6.4 \pm 0.1 \mathrm{~m} / \mathrm{s}$
C. $6.35 \pm 0.25 \mathrm{~m} / \mathrm{s}$
D. $6.4 \pm 0.5 \mathrm{~m} / \mathrm{s}$
E. $6.4 \pm 2.5 \mathrm{~m} / \mathrm{s}$
5. A satellite uses an infrared radiometer to indirectly measure the surface temperature of the ocean off the coast of British Columbia. The temperature is measured 5 times in the same week, and the measurements reported are $10.40,10.35,10.31,10.56$, and 10.43 , all in degrees Celsius $\left({ }^{\circ} \mathrm{C}\right)$. The estimated mean of these five measurements is $10.41^{\circ} \mathrm{C}$. What is the error in this estimated mean?
A. $0.005^{\circ} \mathrm{C}$
B. $0.01^{\circ} \mathrm{C}$
C. $0.04^{\circ} \mathrm{C}$
D. $0.1^{\circ} \mathrm{C}$
E. $0.25^{\circ} \mathrm{C}$
6. A car and a train move together along straight, parallel paths with the same constant cruising speed of $25 \mathrm{~m} / \mathrm{s}$. Initially they are side-by-side. Suddenly, the car driver notices a red light ahead and slows down with constant acceleration of $-5.0 \mathrm{~m} / \mathrm{s}^{2}$ until it stops. The car remains stopped for 15 seconds. The light turns green, and the car begins to speed up with a constant acceleration of $+5.0 \mathrm{~m} / \mathrm{s}^{2}$ until it reaches its original speed of $25 \mathrm{~m} / \mathrm{s}$. During the same time interval, the train continues to travel at the constant speed $25 \mathrm{~m} / \mathrm{s}$. How far behind the train is the car after it has reached its original speed again?
A. 130 m
B. 250 m
C. 380 m
D. 500 m
E. 630 m
7. A baseball is hit at angle $\theta$ above the horizontal, and is caught at the height from which it was hit, a horizontal distance, $d$, away. $g$ is the acceleration due to gravity. The initial speed of the ball when it is leaving the bat is
A. $\sqrt{\frac{g d}{2 \sin \theta \cos \theta}}$
B. $\sqrt{\frac{g d}{2 \sin \theta}}$
C. $\sqrt{\frac{g d}{\sin \theta \cos \theta}}$
D. $\sqrt{g d \tan \theta}$
E. $\sqrt{g d \sin (2 \theta)}$
8. A box of mass 450 kg is in the back of a truck. The truck is accelerating to the right at $3.2 \mathrm{~m} / \mathrm{s}^{2}$. The box does not slide. What is the magnitude of the force of static friction on the box?
A. 700 N
B. 1400 N
C. 4400 N
D. less than 440 N
E. not enough information to determine

## FREE-FORM IN THREE UNRELATED PARTS (12 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 (4 points)
The position of a point P on a wheel is described by an angle $\theta$, measured counterclockwise relative to a horizontal line, which passes through the wheel axle. At time $t=0$, the point P is at its highest point, with an initial angular position of $\theta_{0}=+\pi / 2$, as shown in the figure. The initial angular velocity is $\omega_{0}=-2.0 \pi \mathrm{rad} / \mathrm{s}$ (the wheel is initially turning clockwise). The wheel is connected to a motor which causes it to have a constant angular acceleration of $\alpha=+0.40 \mathrm{rad} / \mathrm{s}^{2}$. At what time $t_{1}>0$ does the point P first pass this highest point again? [Please write your final answer in the box provided, and express your answer to 2 significant figures.]


PART B (4 points)
In the Practicals a student uses the computer-based ultrasonic motion sensor to measure distance versus time for a cart. The cart has low-friction wheels and is on a straight 2.2-metre aluminum track that is tilted at some angle. The cart is released from rest at time $t=2.7 \mathrm{~s}$, and distance data is collected at a rate of about 10 measurements per second until $t=9.1 \mathrm{~s}$. Over this time, the distance increases from 57 cm up to 200 cm as the cart slowly rolls down the slope. A polynomial function of $t$ is fit to the data:

$$
\text { Distance }(\mathrm{cm})=\mathrm{a} 0+\mathrm{a} 1 t+\mathrm{a} 2 t^{2}
$$

Where $t$ is the time in seconds, and a 0 , a1 and a 2 are the fit coefficients. The fit is shown below. The best fit gives:

- $\mathrm{a} 0=64 \pm 0.31 \mathrm{~cm}$
- $\mathrm{a} 1=-10.95 \pm 0.11 \mathrm{~cm} / \mathrm{s}$
- $\mathrm{a} 2=2.8792 \pm 0.0094 \mathrm{~cm} / \mathrm{s}^{2}$

From this fit, what would you conclude is the acceleration of the cart? [Please write your final answer in the box provided, and include the error in your estimate.]


PART C (4 points)
A tow rope pulls a skier up a snow-covered hill at a constant speed. Draw the free-body diagram of the skier. Please choose the forces from the following list of six possibilities, and use the symbols given when you label the force vectors. Not all of these forces may actually be acting on the skier. Please draw the free-body diagram within the box provided below.

- Gravitational force: $\vec{F}_{\mathrm{G}}$
- Spring force: $\quad \vec{F}_{\mathrm{sp}}$
- Tension: $\vec{T}$
- Normal force: $\vec{n}$
- Static friction: $\vec{f}_{\mathrm{s}}$
- Kinetic friction: $\vec{f}_{\mathrm{k}}$

