HARLOW	JASON	SOLUTIONS	
Last Name/Family Name **as on student card**	First Name(s) **as on student card**	Student Number	Practical Group Code (ie T3A)

PHY131H1F
Term Test — version A
Tuesday, November 13, 2018
Duration: 80 minutes
Maximum Mark: 32

Aids allowed: A pocket 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. A coin or similar object for the scratch-off card.

- **Completely turn off** any communication device you may have and put it under your chair.
- **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 scratch-off card you will soon receive. **Please put your student number where the scratch card says "Subject".**

Multiple choice questions: There are **12** multiple-choice questions, worth 2 points each, or altogether 24 points. When the test begins, you will be given a scratch-off card with options A, B, C, D for each of the multiple choice questions. Your grade for each question is:

- 2 marks if you scratched only one option and revealed the star.
- 1 mark if you scratched two options and revealed the star.
- 0.2 marks if you scratched three options and revealed the star.
- 0 marks if you scratched all four options or if you do not reveal the star.

Note that scratching any portion of a box is considered to be scratching the entire box. **Be sure of your answer before scratching.** Double check the question number and the letter before you scratch your answer.

Written answer question: To be awarded maximum credit, you must show each step in the problem-solving strategy clearly, completely and correctly. You may earn up to 2 points per step (for a total of 8 points). The four problem-solving steps are:

1. Sketch and translate
   - Sketch the process described in the problem statement. Label the physical quantities and identify unknowns.
   - Identify an appropriate system.
2. Simplify and diagram
   - Identify what simplifying assumptions are necessary to solve the problem.
   - Construct all relevant diagrams: motion diagram, force diagram, momentum bar chart, energy bar chart
3. Represent mathematically
   - Using your representation(s) in Step 2, clearly apply the relevant physics model (such as Newton's second law) to relate known physical quantities to the unknown quantity for which you wish to solve.
   - Do not plug in numbers immediately.
4. Solve and evaluate
   - Rearrange the equation and solve for the unknown quantity.
   - Substitute known values for variables in your expression and include units. Clearly indicate your final answer.
   - Verify that your answer is reasonable with respect to sign, unit, and magnitude. If not, don't panic, but do justify why.

Possibly helpful information for this test:

$\pi = 3.14159$ is the ratio of the circumference to the diameter of a circle

$g = 9.80\ \text{m/s}^2$ is the acceleration due to gravity near the Earth's surface.

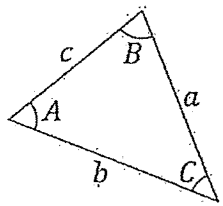
$1\ \text{L} = 1000\ \text{cm}^3$

There are 60 seconds in a minute, 60 minutes in an hour, 24 hours in a day, and 365.24 days in a year (as defined by the Earth finishing one complete rotation around the Sun).

Common Prefixes:

k = "kilo-" = 10^3 c = "centi-" = 10^{-2} m = "milli-" = 10^{-3} μ = "micro-" = 10^{-6}

n = "nano-" = 10^{-9}



Sine rule: $\dfrac{a}{\sin(A)} = \dfrac{b}{\sin(B)} = \dfrac{c}{\sin(C)}$

Cosine rule: $a^2 = b^2 + c^2 - 2bc\cos(A)$

Air resistance may be neglected in all questions, unless otherwise stated. That may be an important assumption which you are expected to articulate.

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

Consider a head-on, perfectly elastic collision of an object with mass m_1 having initial velocity v_{1i} in the $+x$-direction, with an object of mass m_2 that is initially at rest. Both objects move parallel to the x-axis after the collision. The x-components of the velocities of the objects after the collision are given by:

$v_{1f} = \dfrac{m_1 - m_2}{m_1 + m_2} v_{1i}$	$v_{2f} = \dfrac{2m_1}{m_1 + m_2} v_{1i}$

Question 1:

Two thrown balls collide in midair. Which of the following statements best describes the system's momentum **during the collision** if the system includes both balls?

(A) The system's momentum changes a lot due to gravity.
(B) The system's momentum is approximately constant because the time interval is small.
(C) The system's momentum changes a lot because of the large forces between the balls involved in the collision.
(D) The system's momentum is approximately constant because the sum of the external forces is small.

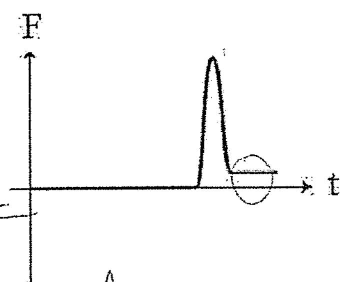
Question 2:

A car moving north is speeding up without changing direction. Which of the following statements best describes the force of friction of the road on the car?

(A) It is static friction and it points south.
(B) It is kinetic friction and it points south.
(C) It is static friction and it points north.
(D) It is kinetic friction and it points north.

Question 3:

Look at the force-time graph on the right. Assume that the force represents just the force described in each scenario. The direction of the force is not specified, so it could be any direction. Which of the following scenarios is consistent with the given force-time graph?



(A) Someone dropped a pillow onto the floor. The pillow did not bounce. The system is the pillow and the force is the force of the floor on the pillow.
(B) Someone threw a dart into the ceiling where it got stuck. The system is the dart and the force is the force of the ceiling on the dart.
(C) Someone dropped a rubber ball onto the floor. The ball bounced up. The system is the rubber ball and the force is the force of the floor on the ball.
(D) Someone threw a book which hit the ceiling then fell back to the floor. The system is the book and the force is the force of the ceiling on the book.

Question 4:

Cart A and cart B have the same mass and both start at rest. Cart A is pushed with a net force F over a distance D. Cart B is pushed with a net force of 2F over a distance D. Which of the following statements about the momenta (p_A and p_B) and kinetic energies (K_A and K_B) are correct?

(A) $K_B < 2\,K_A$ and $p_B < 2\,p_A$
(B) $K_B = 2\,K_A$ and $p_B < 2\,p_A$
(C) $K_B < 2\,K_A$ and $p_B = 2\,p_A$
(D) $K_B = 2\,K_A$ and $p_B = 2\,p_A$

Question 5: Assume no dissipative friction

The engine in a sports car can provide a constant power. At full power, the car can accelerate from zero to speed *v* in time *t*. At this power, how long would it take for the car to accelerate from zero to 3*v*?

(A) 6*t*
(B) 3*t*
(C) 9*t*
(D) $\sqrt{3}t$

t

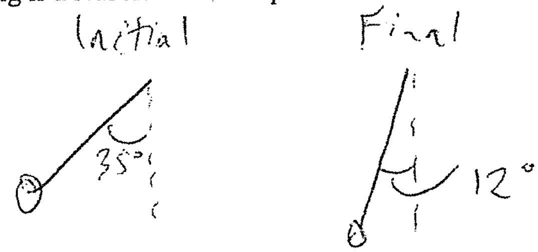
$3v$

$K_{f_2} = 9 K_{f_1} \qquad \Delta t_2 = 9 \Delta t_1$

Questions 6-9 all refer to the following scenario:
A 0.25 kg ball is attached to a string. The string is 34 cm long and has a negligible mass. The other end of the string is fixed to the ceiling, making a simple pendulum. The ball is held such that the string makes an angle of 35° with respect to the vertical. The ball is then released with no initial velocity. We wish to find the tension in the string when the string makes an angle of 12° with respect to the vertical.

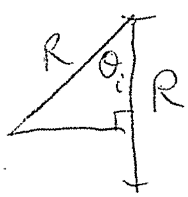
Question 6:
If the system is the ball plus the Earth, which of the following is a reasonable assumption?

(A) The energy is constant.
(B) The acceleration is constant.
(C) The linear momentum is constant.
(D) The velocity is constant.



Question 7:
What is the difference in the height of the ball from 35° to 12°?

(A) 17 cm
(B) 5.4 cm
(C) 28 cm
(D) 12 cm



$y_i = R - R\cos\theta_i \qquad \Delta y = y_f - y_i$

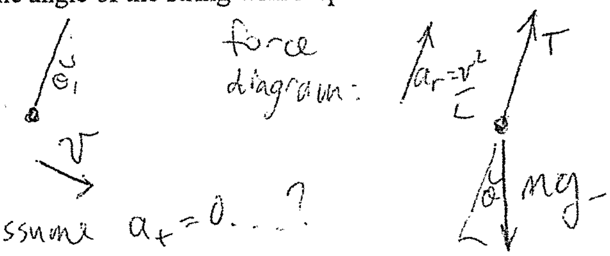
$y_f = R - R\cos\theta_f \qquad = (R - R\cos\theta_f) - (R - R\cos\theta_i)$

$\Delta y = R(\cos\theta_i - \cos\theta_f)$

$\Delta y = 34\,cm(\cos 35 - \cos 12) = -5.4\,cm$

Question 8:
Which of the following equations represents a correct application of Newton's laws to this problem if the system is the ball. Let the mass of the ball be m, the speed of the ball be v, the length of the string be L, the tension of the rope on the ball be T, and the angle of the string with respect to the vertical be θ.

(A) mv² / L = T – mg cos(θ)
(B) 0 = T – mg sin(θ)
(C) 0 = T – mg cos(θ)
(D) mv² / L = T – mg sin(θ)



assume $a_t = 0$...?

Question 9:
What is the tension of the rope when the ball is at 12°?

(A) 3.2 N
(B) 2.4 N
(C) 3.6 N
(D) 2.8 N

$E_i = E_f$

$mgh_i + \frac{1}{2}mv_i^2 = mgh_f + \frac{1}{2}mv_f^2$

$v^2 = 2g(\Delta y)$

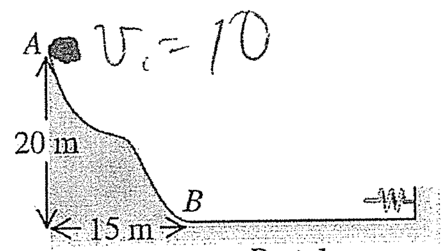
$\Sigma F_r = \frac{mv^2}{L} = T - mg\cos\theta$

$T = \frac{mv^2}{L} + mg\cos\theta$

$= \frac{2mg\,\Delta y}{L} + mg\cos\theta$

$T = (0.25)9.8\left(\frac{2(0.05406)}{0.34} + \cos 12\right) = 3.176\,N$

Questions 10-12 refer to the system shown in its initial configuration below. A 15.0 kg stone slides down a snow-covered hill, leaving point A at a speed of 10.0 m/s. There is no friction on the hill between points A and B, but there is friction on the level ground at the bottom of the hill, between B and the wall. After entering the rough horizontal region, the stone travels 100.0 m and then runs into a very long, light spring with force constant 2.00 N/m. The coefficients of kinetic and static friction between the stone and the horizontal ground are 0.200 and 0.800, respectively. Assume that the distances given in the picture are correct to 3 significant figures (so they should be 20.0 m and 15.0 m).



See Attached.

Question 10:
What is the speed of the stone when it reaches point B?
(A) 19.8 m/s
(B) 29.8 m/s
(C) 22.2 m/s
(D) 25.6 m/s

$v_B = 22.18$ m/s

Question 11:
How far will the stone compress the spring?
(A) 32.9 m
(B) 27.4 m
(C) 16.4 m
(D) 45.8 m

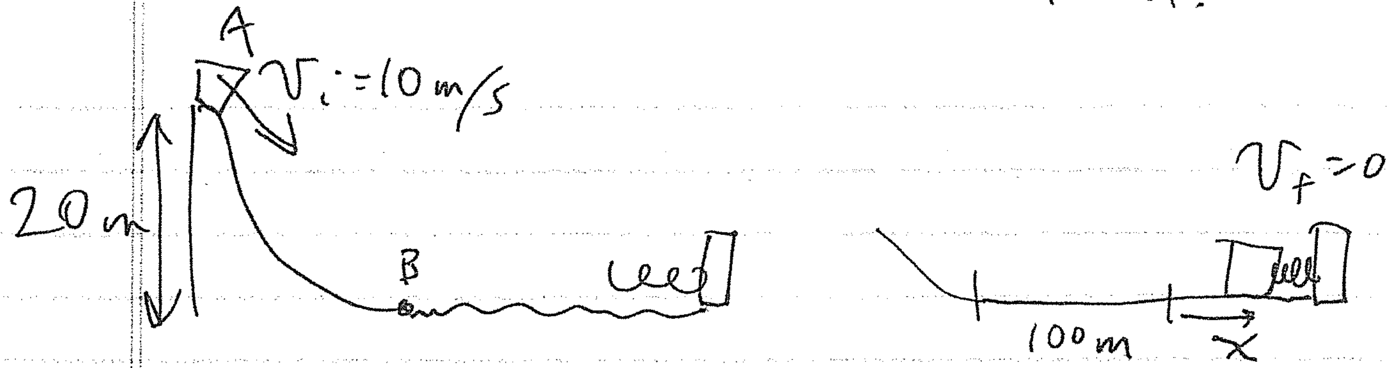
$x = 16.38$ m

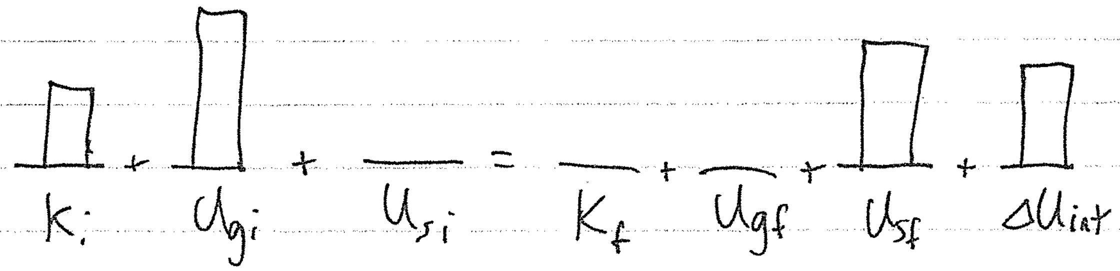
Question 12:
When the spring has reached its maximum compression, what will be the magnitude of the net force upon the stone?
(A) 29.4 N
(B) 32.7 N
(C) 3.36 N
(D) zero

There are no questions 13-25.

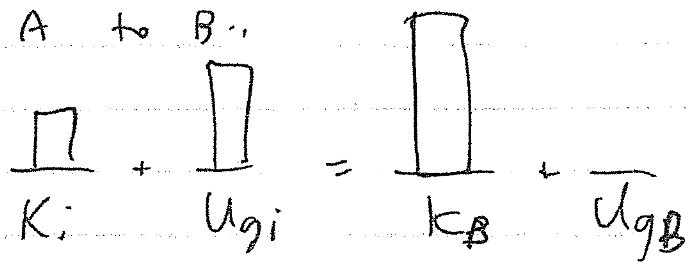
1

Initial. Final.





<u>First Question</u>: A to B:



$$\frac{1}{2}mv_i^2 + mgh_i = \frac{1}{2}mv_B^2$$

$$v_{Ai}^2 + 2gh_i = v_B^2$$

$$v_B = \sqrt{v_i^2 + 2gh_i} = \sqrt{10^2 + 2(9.8)(20)}$$

$$\boxed{v_B = 22.18 \text{ m/s}}$$

i to f:

$$\frac{1}{2}mv_i^2 + mgh_i = \frac{1}{2}kx^2 + \mu_k mg(100 + x)$$

$\frac{1}{2}k x^2 + \mu_k m g x + 100 \mu_k m g - \frac{1}{2} m v_i^2 - m g h_i = 0$

Quadradic Eq. with $a = \frac{k}{2} = 1$

$b = \mu_k m g = 0.2(15)9.8$

$b = 29.4$

$c = 100(0.2)15(9.8) - \frac{1}{2}(15)10^2 - 15(9.8)(20)$

$c = -750$

So.

$x^2 + 29.4x - 750 = 0$

$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a} = \frac{-29.4 \pm \sqrt{29.4^2 + 4(750)}}{4}$

$x = \frac{-29.4 \pm 62.16}{2}$

* → $\boxed{x = 16.38}$ or -45.782 ← reject negative solution.

$F_s = kx = 32.8$ N.

$f_{s,max} = mg\mu_s = 117.6$ N.

$\Rightarrow f_s = F_s \Rightarrow F_{Net} = 0,$

* → $\boxed{\text{zero acceleration}}$

Written Answer Question
Please read the front page for instructions about how to answer this question using the 4-step procedure.

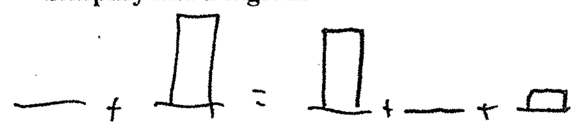
The Leviathan roller coaster at Canada's wonderland has a drop of 93.3 m. The maximum speed of the coaster at the bottom of this drop is 148 km/h. During the drop, what percentage of its initial energy is "lost"? Note that by "lost", we mean the energy is converted non-recoverable internal thermal energy in the coaster and its environment.

Sketch and Translate

Initial. Final.

System = coaster + Earth.

Simplify and Diagram



$K_i + U_{gi} = K_f + U_{gf} + \Delta U_i$

$K_i = 0$, $U_{gf} = 0$

assume $v_i = 0$

assume $y_f = 0$

$y_i = d$.

Represent Mathematically

$mgd = \frac{1}{2}mv_f^2 + \Delta U_{int}$

m = unknown.

Need $\frac{\Delta U_{int}}{mgd}$ ← initial energy

$\frac{\Delta U_{int}}{m} = gd - \frac{v_f^2}{2}$

$v_f = 148\ \frac{km}{hr}\left(\frac{1000\ m/km}{3600\ s/hr}\right)$

$= 41.1111\ m/s$

Solve and Evaluate

$\frac{\Delta U_{int}}{m} = (9.8)(93.3) - \frac{41.111^2}{2}$

$\frac{\Delta U_{int}}{m} = 69.27828$

$\Rightarrow \frac{\Delta U_{int}}{mgd} = \frac{69.27828}{9.8(93.3)}$

$= 0.0758$

7.58% of initial energy is "lost."

This is low, but that makes sense, as roller coasters are powered by gravity and must be fast to be fun