Name (printed neatly) ______________________________

General Physics 121 - Exam 1 – September 23, 2016

Time started ________________

Time ended ________________

Place taken ________________

- To receive full credit for a problem, your work must convincingly demonstrate that you understand the physics involved behind the problem. That means not only providing the correct answer but showing how you obtained your answer.
- Questions represent a mix of conceptual and quantitative issues. Questions are scored according the rubric on the next page
- You may not consult the textbook, your notes, or any source of information other than the equations below.
- Include raw algebraic equations and identify variables. Include units (m, s, m/s, etc.) in calculations and carry them through.
- You may choose any continuous, uninterrupted 3-hour period in which to take this exam.
- You may use a calculator provided it is not programmed with course-specific information.
- It is important that your answers be neat and clear. Legible handwriting and clear exposition are required, not optional.
- Use only one side of each page of paper.
- Box your final answers to help me locate and identify them quickly
- Use your own, lined paper. Nothing written on this exam will be graded. Do not use paper ripped from a spiral-bound notebook with jagged edges.
- Do not write your name on any of the pages other than this cover sheet.
- Start each answer on a new sheet of paper.
- When finished, place this exam atop your paper and staple them together with your responses to the questions in sequential order before handing them in.
- You must turn in the exam to Dr. Pontius unless other arrangements have been made.
- **I reserve the right to assign additional penalties for violating these instructions.**

Signing the honor code also affirms that you are taking the exam during a time period that does not conflict with any other academic obligations.

Honor code:

Reminder: Show all your work. Explain thoroughly and justify everything.

Don't Panic!

$$\Delta x \equiv x_f - x_i \qquad \Delta t \equiv t_f - t_i \qquad \Delta v_x \equiv v_{xf} - v_{xi}$$

$$v_{x,\,av} \equiv \frac{\Delta x}{\Delta t} \qquad v_x = \frac{dx}{dt} \qquad v_{xf} = v_{xi} + a_x \Delta t$$

$$a_{x,\,av} \equiv \frac{\Delta v_x}{\Delta t} \qquad a_x = \frac{dv_x}{dt} \qquad v_{xf}^2 = v_{xi}^2 + 2\,a_x\,\Delta x$$

$$\vec{F}_{net} = m\,\vec{a} \qquad F_g = m\,g \qquad x_f = x_i + v_{xi}\,\Delta t + \frac{1}{2}a_x(\Delta t)^2$$

$$f_{s,max} = \mu_s F_n \qquad f_k = \mu_k F_n \qquad \vec{F}_{12} = -\vec{F}_{21}$$

$$a_r = \frac{v^2}{r} \qquad v_{av} = \frac{v_f + v_i}{2} \qquad \vec{\mathbf{r}} = x\hat{\mathbf{i}} + y\hat{\mathbf{j}} + z\hat{\mathbf{k}}$$

g = 9.80 N/kg — 1 N = 0.225 lb — $c = 3.00 \times 10^8$ m/s
1 mile = 1619 m — 1ft = 0.305 m — 1 inch = 2.54 cm
1 ton = 10^3 kg — 1 mile = 1.609 km — 1 Btu = 252 cal

Coefficients of friction	Static	Kinetic
Glass against glass	0.94	0.40
Wood against rubber	0.98	0.67
Wood against wood	0.43	0.37
Wood against concrete	0.62	0.45
Rubber against concrete	0.95	0.80
Kitten against carpet	2.57	-

Grading rubric:

Level of demonstrated understanding	Example	Score
Complete	Correct reasoning and answer	10
	Correct reasoning; minor computational mistakes or omissions; reasonable answer	9
Partial	Some physics errors or a correct setup but no or incomplete execution; substantial omissions	7
	Major physics errors or partial justification provided even if answer is correct; major omissions	5
Little to none	Little of relevance or no justification provided even if answer is correct	3
	Very little of relevance; moderately interesting B. S.	1
	Blank or just a restatement of the question	0

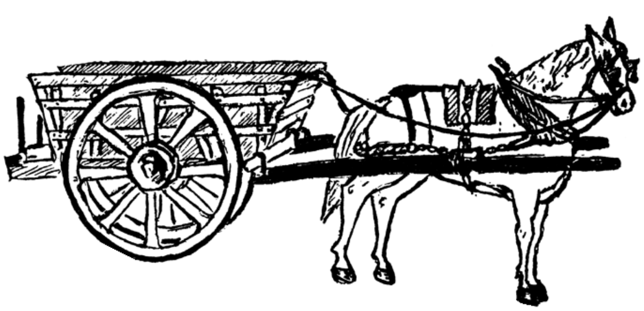
1. Imagine throwing a ball straight upward as high as you can. The ball is first at rest in your palm. As you raise up your arm, the ball travels along with your palm until it leaves your hand. It travels to the highest point of its trajectory and then falls back down to the ground. You may neglect any air resistance. Sketch a **velocity versus time** graph corresponding to the motion of the ball described above. Mark the following instants on your graph:

a) ball first set in motion after being at rest
b) ball leaves hand
c) ball reaches the highest point of its trajectory
d) ball hits ground

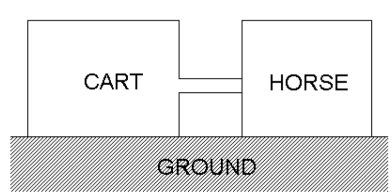
Explain what characteristics of your drawing allow you to make each identification and explain how you determine what the graph looks like between those points.

2. The world record in high diving is currently held by Dana Kunze, who plummeted some 52.4 meters into a swimming pool. Mr. Kunze (who tips the scale at a svelte 190 pounds) performed a triple summersault on the way down before plunging feet first into the water. Assuming he plunged below the surface to a depth one tenth his initial height above the surface, find the average force exerted on him by the water as he slowed. Explain your logic thoroughly.

3. A horse is pulling a wagon at constant speed over a flat, horizontal road. Draw one free-body diagram of all the forces acting on the horse and another one of all the forces acting on the wagon. (Work from the physicist's version below.) Explain the physical origin of each force and make clear which force acts on which object. In your drawing, indicate the relative magnitude of the forces and identify any third-law force pairs. Separately, identify forces of equal magnitude that are not third-law pairs and argue why they are equal. Explain everything.

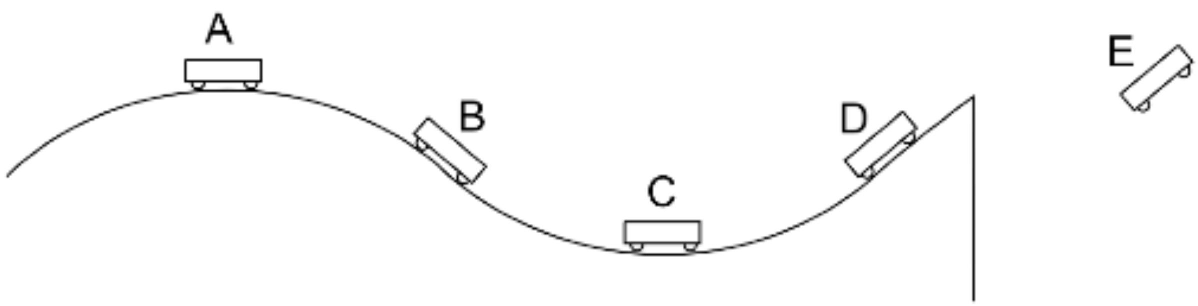


Artist's Impression

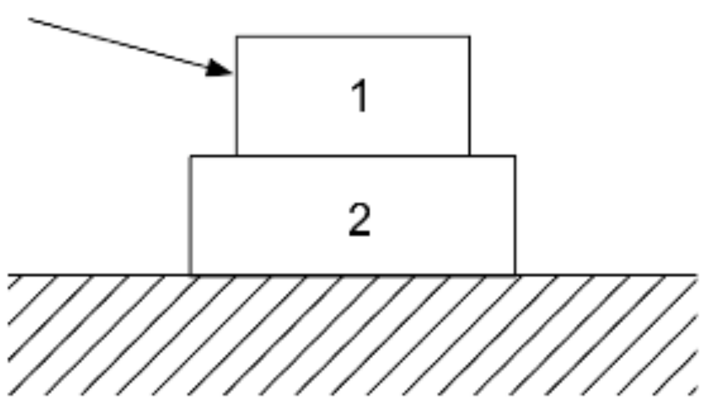


Physicist's Impression

4. Consider the illustration below of an exciting new roller coaster. Slick, aerodynamic (i.e., frictionless) cars speed onto the track from the left and move along the curved track, finally flying off the escarpment on the far right to eventually land in a lake (not shown). On your own paper, draw free-body diagrams for the cart at each of the labeled positions. Beside each free-body diagram, indicate the directions of velocity and acceleration, and explain how those are related those to your force vectors. The relative lengths of the various vectors should be qualitatively accurate (longer ⇒ stronger, etc.) and should remain reasonably consistent from one figure to the next. For each, explain your reasoning.



5. Two blocks of wood are stacked upon each other, as shown below, and the lower one rests on a flat concrete surface. The mass of block 1 is m_1 = 23.6 kg while the mass of block 2 is m_2 = 58.5 kg. Starting with both at rest, the upper one is pushed on with a force of 83.6N along a line directed 15° below the horizontal. Calculate the **total** force exerted by the concrete surface on block 2 some time later while the same applied force is still acting. Explain your reasoning.



6. Prior to the arrival of the conquistadors, Mayans played a team sport called Tlachtli that involved a solid rubber ball, and courts still exist in the ruins at Tikal. Similar to soccer, players could not use their hands, but like basketball, scoring required putting the ball through a hoop at one end of a court. However, for Tlachtli the hoop was oriented vertically, made of stone, and positioned 4 meters above the playing surface, making slam dunking much rarer than today. Let's assume you are a player standing a horizontal distance of 15 meters from the position beneath the goal. The ball is on the court at your feet and you want to kick it through the goal. Find **any** initial velocity that will accomplish that, giving both speed and direction. Demonstrate that your choice does indeed score for your team.

By the way, Professor Dorman is sponsoring an Exploration Term trip to Central America that will visit Tikal and other classical Mayan sites. If you are interested, please contact him right away because he is eagerly seeking additional students. This is an exceptional opportunity!

Extra credit. DO NOT ATTEMPT THIS ONE UNLESS YOU ARE VERY CONFIDENT THAT YOU HAVE COMPLETED EVERYTHING ELSE ON THIS EXAM CORRECTLY!

A moving guy (you know, the kind that drive those humongous trucks bigger than your house) puts a cardboard box onto a loading ramp, and it slides down it at a constant speed. The other guy waiting at the bottom of the ramp yells, "hey, bozo, dat one's for annudah place!" He gives the box a shove that sends it back up the ramp, but it doesn't make it all the way to the top. "Must be friction," he says, "dat tangential contact force we learned 'bout in college." So if he had given it the same upward starting speed but there had been no friction acting, how much farther would the box have made it up the ramp compared to how far it actually did make it up? Your answer should be an actual numerical factor