General Physics 1–Honors (PHYS 101H):
Midterm 2
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Overview and instructions

In this midterm you will apply your understanding of conservation of energy, elastic and inelastic collisions, and rotational motion.

Read the following instructions carefully.

There are **five questions**, for a total of **100 points**. **Attempt all questions**. The exam will finish at 11:45 am. Please write your name **on every sheet of paper you submit**. It is helpful if you include page numbers at the bottom of each page, too.

You may use:

- an electronic calculator;
- your own formula sheet, written or printed on two sides of letter paper.

You may **not** use:

- electronic devices (except a calculator), including phones, tablets and laptops (unless previously arranged);
- textbooks or other reference resources;
- course notes or slides.

The first three questions are multiple choice. Your answer to these multiple choice questions should be written out and submitted as part of the rest of your solutions. For example, you could write, "Problem 1: my answer is **(a)**." Do **not** circle the options on the exam itself; I will not collect the exams and you will not receive credit for your answer. **You can receive partial credit for multiple choice questions**.

The remaining questions require written solutions. You should show all your working and include important intermediate steps, equations, and results. You can receive partial credit for these problems, even if you don't complete the problem or provide a correct final answer. Please ensure that you highlight or emphasise your final answer (for example, by circling or underlining the final answer).

You are responsible for ensuring your solutions are legible. Present your solutions legibly and as logically as you can. What this means in practice is the following:

1. Write down what quantities you know.
2. Write down the relevant equations.
3. When carrying out manipulations or substituting values into equations, try to write each equality on separate lines or otherwise distinguish them clearly.

4. Circle or underline your final answers to identify them clearly.

Some hints for tackling problems in general:

1. Try to identify what "kind" or "type" of question is being asked, for example "projectile motion", "conservation of energy", or "two dimensional collision".
2. Draw a labelled diagram.
3. Write down what quantities you know.
4. Write down the relevant equations.
5. Only substitute values at the end of your calculation and try to carry out all manipulations symbolically.
6. Double check the order of magnitude of your answer.
7. Double check the units of your answer.
8. Double check the number of significant figures of your answer. Remember that I am only looking for approximately the correct number of significant digits. If quantities are given to two or three significant digits, quote your answer to two or three (not one or five). Similarly if quantities are given to eight significant digits, do not quote your answer to two.

You do not have to tackle the questions in order. Briefly read through them all and then start on one!

Short questions

Remember, your answer to these multiple choice questions should be written out and submitted as part of the rest of your solutions. You can receive partial credit for multiple choice questions.

Question 1 — 15pts

Two blocks, of mass 1.1 kg and 0.7 kg, are hung from the left and right ends, respectively, of a massless rod of length 1 m. This system is placed on a pivot that is 25 cm to the right of the larger (1.1 kg) mass. The rod is held horizontal and then released from rest. What is the initial angular acceleration of the system?

(a) 10.6 rad/s^2 counter-clockwise
(b) 5.3 rad/s^2 counter-clockwise
(c) 0 rad/s^2
(d) 5.3 rad/s^2 clockwise
(e) 10.6 rad/s^2 clockwise

Question 2 — 15pts

A wheel with moment of inertia $I = mr^2/2$ rolls without slipping along a horizontal table, with angular speed ω. What is the angular momentum of the wheel relative to a dot on the table that coincides with the contact point of the wheel at a certain point in time?

(a) 0 (b) $\frac{mr^2\omega}{2}$ (c) $mr^2\omega$ (d) $\frac{3mr^2\omega}{2}$ (e) $2mr^2\omega$

Question 3 — 15pts

Two masses, each of mass m, collide with each other on a frictionless table. Prior to the collision, one of the masses moves with speed v and the other is stationary. The masses stick together. What is the final kinetic energy of the system, assuming no mass is lost?

(a) 0 (b) $\frac{mv^2}{4}$ (c) $\frac{mv^2}{3}$ (d) $\frac{mv^2}{2}$ (e) mv^2

Longer questions

Remember, present your solutions legibly and as logically as you can. Highlight your final answer by underlining or circling it.

Question 4 — 30pts

A mass of $2m$ moves to the east, and a mass m moves to the west, both with speed v_0. They collide elastically, but not head on, so that the mass $2m$ ends up moving northwards (that is, perpendicular to the original direction of motion). The collision is illustrated in figure 1, where the dashed arrows indicate the velocities before the collision and the solid arrows indicate the velocities after the collision. Show that the speed of the mass $2m$ after the collision is $v_0/\sqrt{3}$.

Hint: the final speed (squared) of the mass m is given in terms of its components by $v^2 = v_{\text{North}}^2 + v_{\text{East}}^2$.

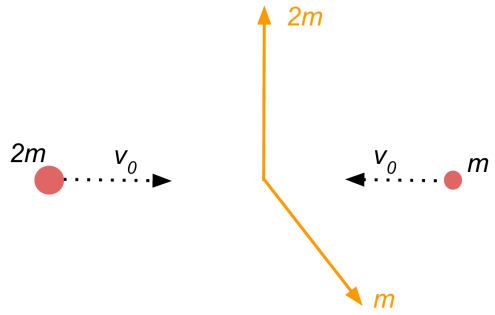

Figure 1: Diagram for Question 4.

Question 5 — 25pts

A block of mass $m = 4.00$ kg is held against a spring with a spring constant of $k = 1500$ N/m, compressing the spring by a distance $x = 0.03$ m. The block is released and the spring extends, pushing the block along a rough horizontal surface. The coefficient of kinetic friction between the surface and the block is $\mu_K = 0.2$. Find the work done by friction on the block while it moves $x = 0.03$ to the equilibrium position.