General Physics 1–Honors (PHYS 101H): Practice Final Exam Tuesday, December 13, 2022

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Overview and instructions

In this final you will apply your understanding of the topics covered in Physics 101–Honors. These topics include: kinematics and dynamics in one and two dimensions; Newton's laws of motion; conservation of energy; elastic and inelastic collisions; rotational kinematics and dynamics; gravitation; fluid statics and dynamics; simple harmonic motion and oscillations; and wave motion.

Read the following instructions carefully.

There are **ten questions**, for a total of **200 points**. **Attempt all questions**. The exam will start at 9:00 am and finish at 12:00 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 five 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.

The remaining five 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. 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. Write down what quantities you know.
6. Write down the relevant equations.
7. When carrying out manipulations or substituting values into equations, try to write each equality on separate lines or otherwise distinguish them clearly.
8. Circle or underline your final answers to identify them clearly.

Some hints for tackling problems in general:

1. Only substitute values at the end of your calculation and try to carry out all manipulations symbolically.
2. Double check the order of magnitude of your answer.
3. Double check the units of your answer.
4. 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.

Question 1 **15pts**

A cart on a frictionless air track is moving at 0.5 m/s when the air is suddenly turned off. The cart comes to rest after travelling 1 m. The experiment is repeated, but now the cart is moving at 1 m/s when the air is turned off. How far does the cart travel before coming to rest, assuming the coefficient of kinetic friction is constant for both cases?

(a) 1 m (b) 2 m (c) 3 m (d) 4 m (e) 5 m

Question 2 **15pts**

Clifford likes to drop his ball in the river and watch the ball float downstream before swimming after it. The river flows at a constant rate of $u = 1$ m/s, and Clifford watches the ball for 3 s before he starts swimming. Assuming that Clifford can swim with a uniform velocity of 2 m/s^2, how long does it take for Clifford to catch up with his ball? Assume that both the ball and Clifford travel in a straight line downstream.

(a) 1.5 s (b) 3.0 s (c) 4.5 s (d) 6.0 s (e) 7.5 s

Question 3 **15pts**

A siren has a sound intensity level of 100 dB at a distance of 100 m from the siren itself. What is the intensity of the sound at a distance of 1 km from the siren?

(a) 1 W/m^2 (b) 10^{-1} W/m^2 (c) 10^{-2} W/m^2 (d) 10^{-3} W/m^2 (e) 10^{-4} W/m^2

Question 4 **15pts**

Blood flows through a coronary artery that is partially blocked by deposits along the artery wall. Assuming ideal fluid flow, which statements about this blood flow are correct?

(a) The flow speed of the fluid is larger in the wide part of the artery, because the flux is larger in the wide part of the artery.

(b) The flow speed of the fluid is larger in the wide part of the artery, because the flux is the same in the wide part of the artery.

(c) The flow speed of the fluid is the same in the wide part of the artery, because the flux is the same in all parts of the artery.

(d) The flow speed of the fluid is smaller in the wide part of the artery, because the flux is the same in all parts of the artery.

(e) The flow speed of the fluid is smaller in the wide part of the artery, because the flux is smaller in the wide part of the artery.

Question 5 **15pts**

What is the weight of an 70 kg astronaut on the Moon? The mass of the Moon is $0.0123 M_E$, where M_E is the mass of the Earth, and the radius of the Moon is $0.2727 R_E$, where R_E is the radius of the Earth.

(a) 8.4 N (b) 16 N (c) 31 N (d) 187 N (e) 687 N

Longer questions

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

Question 6 **25pts**

An ice skater is spinning at 6.0 rev/s and has a moment of inertia of 0.5 $\text{kg}\,\text{m}^2$.

(a) Calculate the angular momentum of the ice skater spinning at 6.0 rev/s.
(b) The skater reduces their rate of rotation by extending their arms and increasing his moment of inertia. Find the value of his moment of inertia if the skater's rate of rotation decreases to 0.75 rev/s.
(c) Suppose instead the skater keeps their arms in and allows friction of the ice to slow the skater to 3.75 rev/s. What is the magnitude of the average torque that was exerted, if this process takes 14 s?

Question 7 **25pts**

You've been given the challenge of balancing a uniform, rigid meter-stick with nonzero mass M on a pivot. Stacked on the 0-cm end of the meter stick are n identical coins, each with mass m, so that the center of mass of the coins is directly over the end of the meter stick. The pivot point is a distance d from the 0-cm end of the meter stick.

(a) Determine the distance $d = d_1$ if there are n coins on the 0-cm end of the meter stick and the system is in static equilibrium.
(b) Find the approximate value of d in the case where $m \ll M$.
(c) Is it possible to stack enough coins at the 0-cm end to achieve equilibrium with $d = 0$?

Question 8 **25pts**

A massless spring has force constant $k = 180$ N/m and connects a block of wood to a wall. The system is initially at rest, with the spring unstretched. The block has mass $M = 25$ g and is able to move without friction on a table. A gun is positioned to fire a bullet of mass $m = 9$ g into the block along the spring axis. After the gun is fired, the bullet gets embedded in the block, and the spring is compressed a maximum distance $d = 0.8$ m.

(a) What kind of collision is this? What is conserved?
(b) What is the speed of the bullet before it enters the block?
(c) What is the frequency of the resulting periodic motion of the block/bullet and spring system?

Question 9 **25pts**

A 8.0 cm diameter fire hose ends with a 2.5 cm diameter nozzle. The density of water is 1.00×10^3 kg/m^3 and 1 m^3 = 1000 L.

(a) Calculate the pressure drop caused by the narrowing of the nozzle as water enters the nozzle from the hose at a rate of 40.0 L/s.

(b) If the nozzle of the hose is pointed vertically upward, what is the maximum height above the nozzle that the water can rise, neglecting air resistance?

Question 10 **25pts**

The "classical" radius of a neutron is about 0.81 fm (1 femtometre, abbreviated as fm, is 10^{-15}). The mass of a neutron is 1.675×10^{-27} kg and the gravitational constant is $G = 6.67 \times 10^{-11}$ m^3/kg/s^2.

(a) Assuming the neutron is spherical, calculate its density in kilograms per cubic meter.

(b) What would be the magnitude of the acceleration due to gravity, in meters per second squared, at the surface of a spherical neutron star of radius $R = 20$ km with this same density? Note that a neutron star is essentially composed of nothing but neutrons (hence the name).

(c) What would be the escape velocity for such a neutron star?