General Physics I–Honors: PHYS 101H (Fall 2023)
Quiz 5–Solutions

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Instructions

In this quiz you will apply your understanding of dimensional analysis and problem solving techniques in physics. Read the following instructions carefully.

DO NOT TURN OVER THIS SHEET UNTIL INSTRUCTED.

This is a **group quiz**. You **must** work in pairs or in a group of three. Working alone or with a larger group will score zero.

Please write your names on the quiz. All pair or group members should write their name on the quiz and **submit one quiz per pair or group**. You will all receive the same grade for your submission.

You have fifteen minutes to attempt all three multiple-choice questions in this quiz.

In addition to your answer, you must **specify your group's confidence level** for your answer, on a scale of 1 (no idea) to 5 (totally certain). If you do not select a confidence level, you will receive zero for that question.

Your points for each question answered correctly will be multiplied by your confidence level for that question. If you answer incorrectly, the points will be multiplied by 1/4 of your confidence level and deducted. Thus, if you answer question (1) correctly and specify your confidence level as "(4) Confident", you will receive $2 \cdot 4 = 8$ points. If you answer question 1 incorrectly, with the same confidence level, you will lose $2 \cdot 4 \cdot 0.25 = 2$ points. The maximum score is 50 points. The minimum score is zero.

For each question, indicate your answer (or answers) clearly by **circling** the correct option (or options).

You may use electronic calculators, but you will not need one.

You may **not** use:

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

Question 1 — 2pts

Which of the following forces can never, under *any* circumstances, do work (circle your answer(s))?

(a) Gravity; (b) Static friction; (c) Kinetic friction; (d) Tension; (e) Normal force;
(f) None of the above, they can all do work.

Circle your confidence level:

(1) No idea (2) Not confident (3) Somewhat confident (4) Confident (5) Totally certain

Solution 1

The answer is $\boxed{\text{(f)}}$. All of these forces can do work. The tricky ones are static and kinetic friction, which can do work on an object that is resting or sliding on another object that is being pushed. For example, a book resting on a table that is being pushed will experience work done by the friction.

Question 2 — 4pts

A person pulls a box along the ground at constant speed. If we consider the Earth and the box as our system (circle your answer):

1. What is the net force exerted by the person on the system? (a) Zero; (b) Nonzero.

2. What is the net work done by the person on the system? (a) Zero; (b) Nonzero.

Circle your confidence level:

(1) No idea (2) Not confident (3) Somewhat confident (4) Confident (5) Totally certain

Solution 2

The answer to part (1) is $\boxed{\text{(a)}}$. Consider the force exerted on the box: the net force is zero, so $F_{pb} = F_{Eb}$ (here "pb" indicates the force exerted by the person on the box, etc.). Similarly, for the person, $F_{bp} = F_{Ep}$, and for the Earth, $F_{pE} = F_{bE}$. By Newton's third law, $F_{pb} = F_{bp}$ and $F_{Ep} = F_{pE}$. From all of these, we can conclude that F_{pE} has the same magnitude, but opposite direction, to F_{pb} and so the net force on the box+Earth system is zero.

The answer to part (2) is $\boxed{\text{(b)}}$. The displacement of the Earth is zero, so the person does no work on the Earth. However, the displacement of the box is nonzero, so the person does work on the box. The net work done is therefore nonzero.

Question 3 **4pts**

A heap of rope with mass density λ (per unit length) lies on a table. The total length of the rope is L. You grab one end and pull horizontally with constant speed v. Assuming that the rope has no friction with itself and that you pull a length $\ell < L$ straight, what is the force that you must apply to maintain the constant speed as you pull the rope out of the heap (circle your answer)?

a) 0; (b) λv^2; (c) $\lambda \ell g$.

Circle your confidence level:

(1) No idea (2) Not confident (3) Somewhat confident (4) Confident (5) Totally certain

Solution 3

The answer is $\boxed{\text{(b)}}$. The force acting on the rope is

$$F = \frac{\mathrm{d}p}{\mathrm{d}t}.$$

The change in momentum of a short length of rope, with mass $\mathrm{d}m$, is

$$p = \mathrm{d}m \cdot v = \lambda \mathrm{d}x \cdot v.$$

Thus the force is

$$F = \frac{\mathrm{d}p}{\mathrm{d}t} = \lambda v \cdot \frac{\mathrm{d}x}{\mathrm{d}t} = \lambda v^2.$$