

PHYSICS 323 - Fall Semester 2015 - ODU

Modern Physics - Problem Set 2 – DUE THURSDAY, SEPTEMBER 10

GENERAL INSTRUCTIONS:

There are two ways you can submit your solution to all HW problems:

1. As an **email** to skuhn@odu.edu. Your submission **must** be sent **before 11:59 p.m.** on the day on which the Problem Set is due. The email must contain the **complete** solution, if at all possible typed or typeset. If a question requires you to display mathematical formulas (e.g., some algebraic manipulations), you can either write those in the form of some programming language (e.g., “4*3 = 12”) or you can attach a document (Mathematica, Word, .pdf, LaTeX,...) or a scanned hand-written solution. Similarly, graphs and plots have to be either computer-generated or (neatly!) drawn by hand. Any hand-written material must be scanned or photographed and attached to your email as a .pdf or .jpg file.
2. As a hardcopy at the beginning of class. I still encourage you to use computer typeset printout as much as possible (to increase readability), or at least write clearly and neatly!

IN ALL CASES, make sure that your full name and student UIN appears on all your submissions (in the **body** of the email and **inside any attached file** for case 1) to guarantee you get credit for your work! Also, do **not** simply copy someone else’s solution (honor code!) – you can ask for help if you get stuck, but you must submit your **own** work.

Please follow the following format: For each problem (part), type the problem number (e.g., “1a” or “2c”), followed by a SPACE, and then your solution. For “yes/no” questions, enter “Y” or “N” (or “T”/“F” for “true/false” questions), for multiple choice questions, enter the correct choice(s) (“1” or “2” or “3,4” etc.) without any additional characters, and for numerical questions, enter the result in the form “3.1415” or “3.1415e12” (to within $\pm 10\%$ accuracy at least). For conceptual and computational questions, just enter the text and equations (see above).

Problem 1

Please answer the following questions with “Y” or “N”:

- 1a) Within our own (inertial) system, we observe two flashes that are separated by 3 km distance and occur $5 \mu s$ apart. Is the space-time separation between these two flashes space-like?
- 1b) Is there any (hypothetical) inertial system S' where the same two flashes can have a time-like separation?
- 1c) Again concerning the two flashes, is there any system in which their time-ordering is opposite to the one I observe?

Problem 2

The following is a set of multiple choice questions. Answer each with a single digit number.

- 2a) Consider two inertial systems S and S' , where S' moves along the x -axis of S with speed v . (Assume the corresponding axes in S and S' are all parallel to each other and the origins of S and S' coincide). Which of the following statements is true?
1 – Both S and S' measure the same speed for a ball moving in the x -direction

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- 2 – Both S and S' measure the same length for a pole (stationary in S) that is pointing in the y-direction
- 3 – Both S and S' measure the same speed for a ball moving in the y-direction
- 4 – Both S and S' measure the same velocity **vector** for a light wave moving in the z-direction (i.e. the same three components of that vector)
- 2b) A spaceship with relative speed $0.9c$ passes Earth at the moment when both its clock and a clock on earth read $ct = ct' = 0$ m. A short while later, the ship's clock ticks off $ct' = 1$ m (we call this "the event"). Which of the following statements is **not** true?
- 1 – According to an observer on Earth, this event is in the absolute future of the origin.
- 2 – For **any** observer, the event has a time-like separation from the origin
- 3 – The invariant interval Δs^2 between this event and the origin, according to Earth, is 1 m^2
- 4 – The event happens at $ct = 1$ m, according to Earth's clock.
- 2c) A 20 m long stick (S') is flying with 90% of the speed of light along the x-axis relative to S. From our vantage point (S), it flies behind and parallel to a building that is 10 m long in the x-direction. Which of the following statements is **not** true?
- 1 – The stick appears to have a length of only 8.72 m in S.
- 2 – At some point in time, the stick is observed (according to careful measurements in S) to be behind the building in its entire length.
- 3 – The stick does not have a "true" (rest) length – it is completely arbitrary which coordinate system one uses to measure its length, and every coordinate system will give a different but equally valid answer.
- 4 – From the point of view of S', the building is way too short to obscure the stick at any time.

Problem 3

Two supernovae go off in our "cosmic neighborhood" – one at the stroke of midnight on December 31, 2020, and the second exactly 80 years later. Careful measurements show that the first supernovae was located at $x = -20 \text{ ly}$, $y = 0$ and $z = 0$ in Earth's coordinate system (S), while the second was located at $x = +20 \text{ ly}$, $y = 30 \text{ ly}$ and $z = 0$.

- 3a) What is the invariant interval Δs^2 between the two supernova explosions?
- 3b) How fast would a spaceship have to travel (relative to Earth) to be present at BOTH explosions? (Never mind that the first one would destroy it...)
- 3c) How much time would have elapsed, according to that spaceship's clock, between the two explosions?

Problem 4

Show algebraically that if you have two numbers u and v that are both inside the interval $[-1 \dots 1]$, then the expression $\frac{u+v}{1+uv}$ can never have a magnitude larger than 1. Explain how this proves that an object moving with velocity smaller than or equal to the speed of light in ONE inertial system can never move with a velocity greater than the speed of light relative to any other inertial system.