Name:_____

Student ID number:_____

Discussion section:_____

Start time:_____

End time: _____

1	15	
2	20	
3	25	
4	25	
5	15	
total	100	

Physics 1C, Winter 2021

Midterm 1, January 27, 2021 (Wednesday, Week 4)

Version B

READ THE FOLLOWING CAREFULLY

- This exam is "open" book. You may use the textbook, class materials, and your handwritten notes and homework. You may also use a calculator or a spreadsheet. You may not consult other people, other printed material, other software, or the internet.
- This exam consists of 10 pages (including this one) with problems numbered 1 through 5. Recall that your solutions pdf that you upload must have the same number of pages.
- You have 1 hour to complete the exam. We are allowing an extra 0.5 hr for the upload.
- Partial credit will be given. Show as much work/justification as possible (diagrams where appropriate). If you cannot figure out how to complete a particular computation, a written statement of the concepts involved and qualitative comments on what you think the answer should be may be assigned partial credit.
- Mistakes in grading: If you find a mistake in the grading of your exam, alert the instructor within two days of the exams being returned (this will occur in discussion section following the exam date).

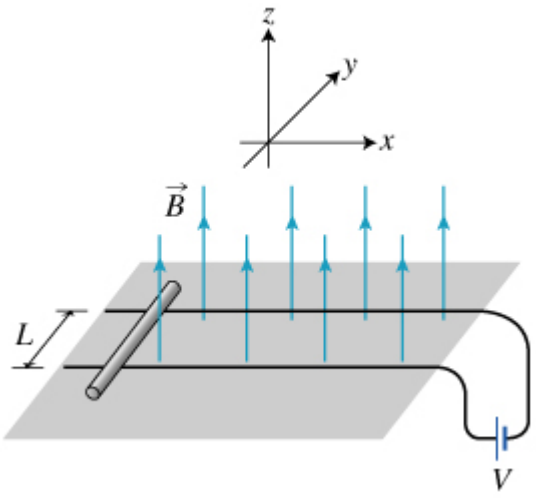
Name:_____

1) A rail gun uses electromagnetic forces to accelerate a projectile to very high velocities. The basic mechanism of acceleration is relatively simple and can be illustrated in the following example. A metal rod of mass m and electrical resistance R rests on parallel horizontal rails (that have negligible electric resistance), which are a distance L apart. The rails are also connected to a voltage source V, so a current loop is formed. (See the figure below.)

The rod begins to move if the externally applied vertical magnetic field in which the rod is located reaches the value B_0. Assume that the rod has a slightly flattened bottom so that it slides instead of rolling. Use g for the magnitude of the acceleration due to gravity.

a) 10 pts Express the coefficient of static friction μ_s in terms of the variables given.

b) 5 pts Does the metal rod move to the left or to the right? (The longer bar on the voltage source indicates the positive side.)



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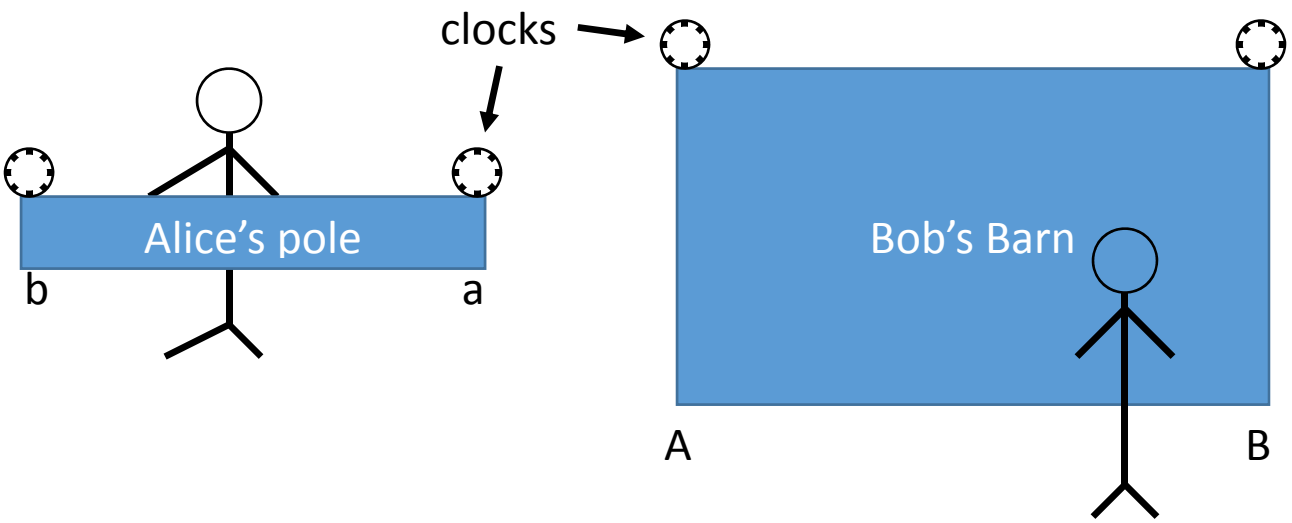
2)



Alice is carrying pole that has length (the distance from b→ a) ℓ_0=15m in her frame. She is running with **β**=**v**/c=(4/5)**x̂** from left-to-right through Bob's barn, which has length (the distance from A → B) L_0=20m in his frame. Both Alice and Bob have coordinate systems with origin (t=t'=0 s and x=x'=0 m) corresponding to the event aA, when the front of the pole (a) gets to the front of the barn (A). The position coordinates (x and x') increase to the right. When asked for a time, you may leave your answer in the format $d/\beta\, c$ (where d is a distance), as we did in class.

i) 10 pts According to Bob, when the front of the pole (a) gets to the back of the barn (B), what is the time t'? At what x' location is the back of the pole (b)? Is the pole inside the barn?

ii) 10 pts According to Alice, when the front of the pole (a) gets to the back of the barn (B), what is the time t? At what x location is the front of the barn (A)? Is the pole inside the barn?

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3) A particle of mass M is moving with non-zero velocity $\mathbf{v} = c\,\beta\,\hat{\mathbf{x}}$ through your lab when it decays into three particles with equal mass m = 2M/7. These new particles all have $v_y = v_z = 0$. One of them also has $v_x = 0$ in the lab frame. Assume that, after the decay, one of the three particles (not necessarily the same particle) is at rest in the center of mass frame.

a) 5 pts Without doing any calculations, describe what is happening in the center of mass frame after the decay and draw a picture. Label the 3 masses #'s 1, 2, and 3.

b) 5 pts Draw a picture showing what is happening in the lab frame after the decay.

c) 10 pts What is β? (Hint: the calculation is not very messy.)

d) 5 pts In the lab frame, what are the β's of the particles with $v_x \neq 0$? Give exact answers in terms of fractions and/or square roots (not decimals).

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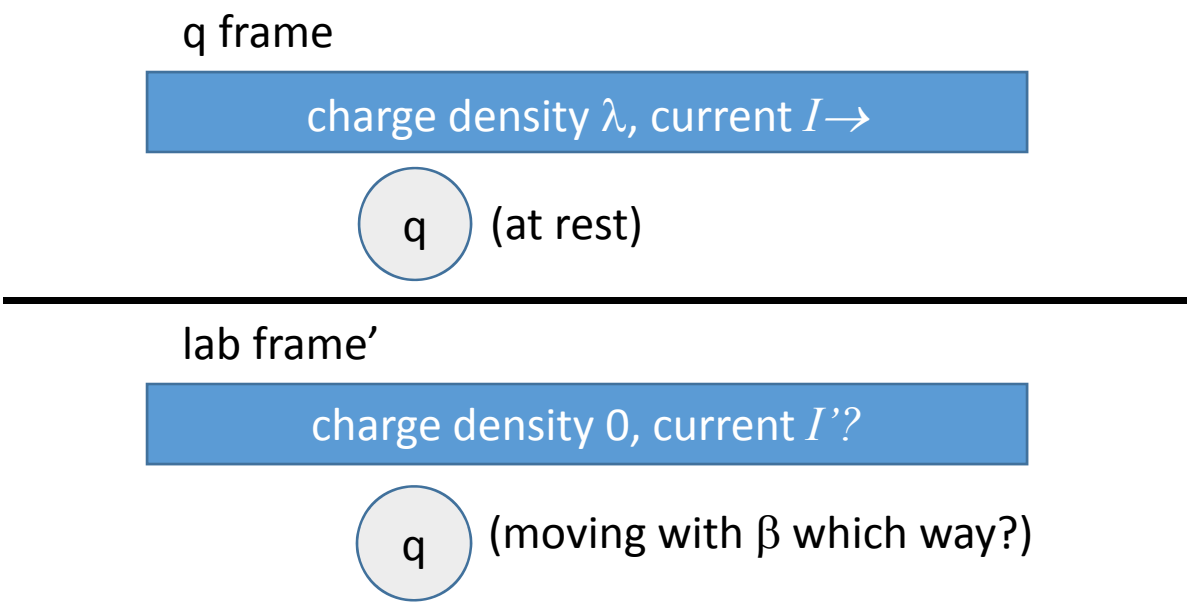

4) In its own rest frame, a charge q sees a wire with linear charge density λ carrying current $\boldsymbol{I} = I\,\hat{\mathbf{x}}$ with $I=|I|>0$. In the lab frame the wire is uncharged, the wire carries current $\boldsymbol{I'}$, and the charge q is moving with $\boldsymbol{\beta}$.

a) 8 pts What is $\boldsymbol{I'}$ in terms of λ and $\boldsymbol{I}$?

b) 4 pts Which way is the charge q moving in the lab frame? Explain.

b) 8 pts What is $\boldsymbol{\beta}$ in terms of λ and $\boldsymbol{I}$?

c) 5 pts Say you are given λ = 1 C/m and I= 300 A. Calculate β, or criticize these values.

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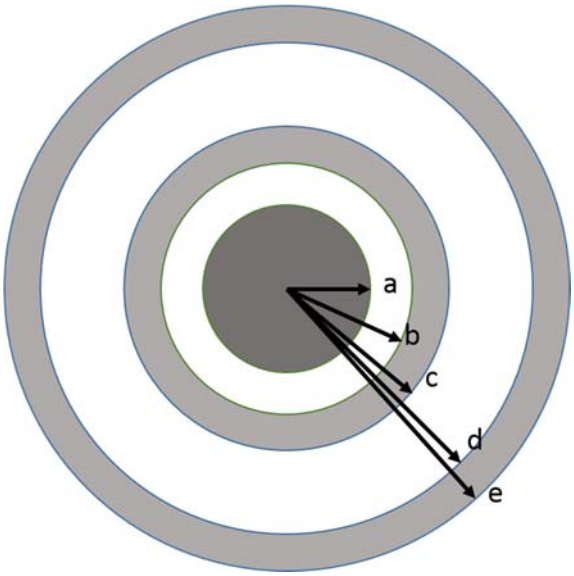

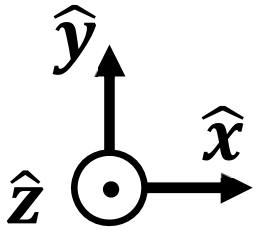

5) 15 pts The figure above shows a cross-section through a tri-axial cable that extends infinitely far into and out of the page. The center conductor (from radius 0 to a) carries current $\boldsymbol{I_1}$= 3 I **ẑ**. The middle conductor (from radius b to c) carries current $\boldsymbol{I_2}$= -5 I **ẑ.** The outer conductor (from radius d to e) carries current $\boldsymbol{I_3}$= 2 I **ẑ**. What is the magnetic field $\boldsymbol{B}(r)$ in the region with radius r between d and e?

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