Name:
Student Number:

Physics 200 Midterm #1

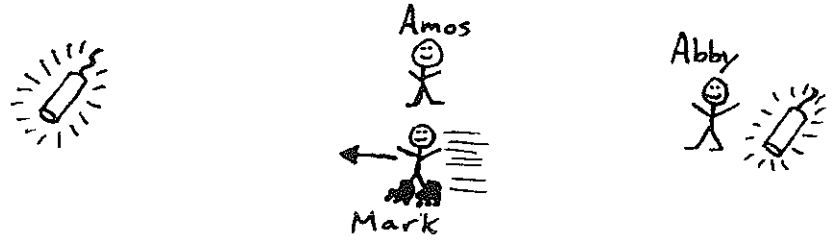
October 12, 2011

Questions 1-8: Multiple Choice: 1 point each
Questions 9-11: Show your work: 9 points total

Multiple choice answers:

#1	
#2	
#3	
#4	
#5	
#6	
#7	
#8	

Formula sheet at the back (you can remove it)

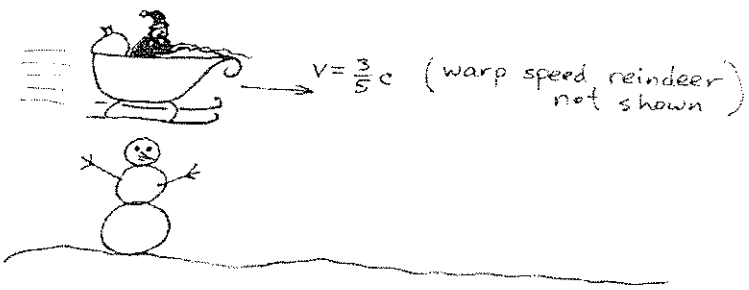


Question 1: Amos, standing directly between two firecrackers, sees both go off at the same time. In the reference frame of Abby, standing near the right firecracker, which explodes first?

A) The left firecracker
B) The right firecracker
C) They explode at the same time
D) Not enough information

Question 2: In the scenario above, Amos sees Mark pass by, moving to the left, just when he sees the firecrackers explode. In Mark's frame of reference, which firecracker explodes first?

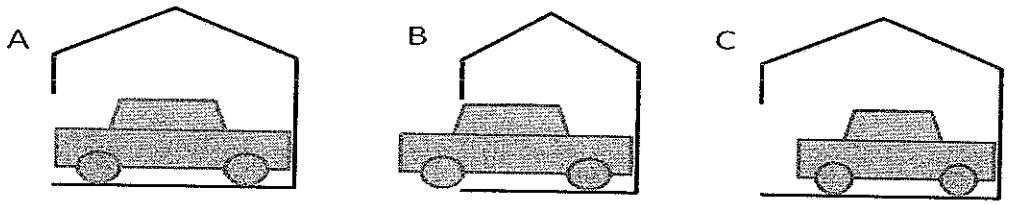
A) The left firecracker
B) The right firecracker
C) They explode at the same time
D) Not enough information



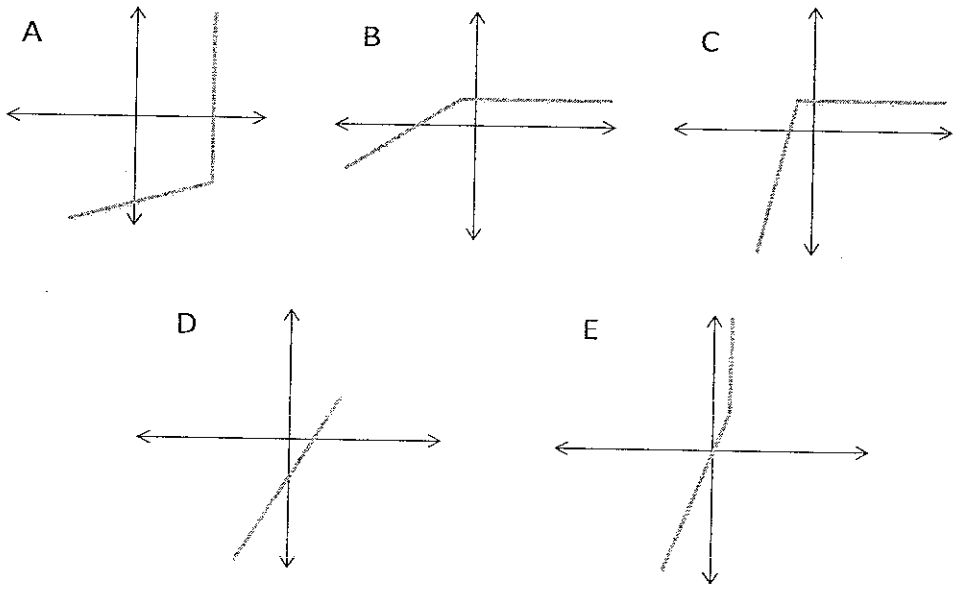
Question 3: Santa flies past Frosty at speed 3/5c. At the instant they pass, both Santa and Frosty set their watches to 9:00. In Santa's frame of reference, what time does Frosty's clock read when Santa's clock reads 10:00?

A) 8:00 B) 9:36 C) 9:48 D) 10:00 E) 10:15

Question 4: A car with proper length 5m travels at 3/5 the speed of light towards a garage with proper length 4m. Which of the pictures below best represents some instant in time in the ***frame of the car***?



Question 5: Which of the following spacetime diagrams shows an object that moves to the right at a constant velocity and then stops?



Question 6: You drive to Surrey and back at 30 km/hr (two hours total) while your friend stays home. If you were exactly the same age before your trip, then after your trip you will be

A) about 10^{-4} hours younger than your friend
B) about 10^{-8} hours younger than your friend
C) exactly the same age as your friend
D) about 10^{-8} hours older than your friend
E) about 10^{-4} hours older than your friend
F) Insert Surrey joke here.

Question 7: At what time does the ball pass over the tree in the frame of the rocket (whose velocity is -u)? Assume that observers in the rocket and on the ground agree on the origin of coordinates and that the picture represents time T in the frame of the ground.

A) $t' = \gamma(T + \frac{u-w}{c^2}D)$

B) $t' = \gamma(T + \frac{u-w}{c^2-uw}D)$

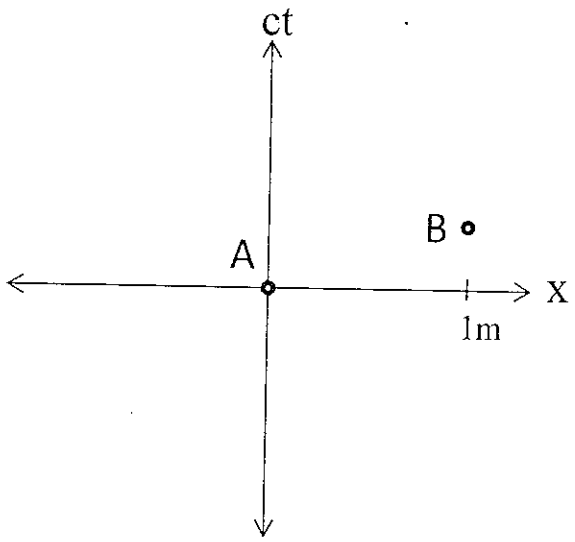
C) $t' = \gamma(T + \frac{u}{c^2}D)$

D) $t' = \gamma(T + \frac{u}{c^2}(D-L))$

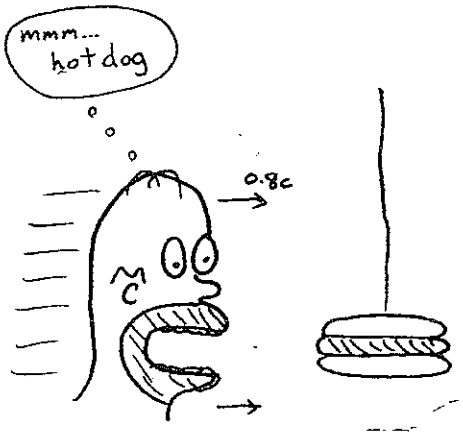
E) $t' = \gamma(T + \frac{w}{c^2}D)$

Question 8: In the spacetime diagram shown, the distance between the events A and B in the frame where they are simultaneous is:

A) less than 1m
B) equal to 1m
C) greater than 1m
D) there is no frame in which they are simultaneous



Question 9: ***(4 points)***



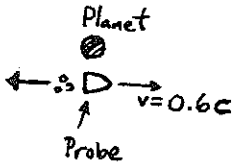
Homer Simpson would like to eat a large hot dog (length L) in one bite, but the distance between the front and back of his mouth is only 2/3 the length of the hot dog. Based on his knowledge of Einstein's theory of Special Relativity, Homer decides to run at 4/5 times the speed of light toward the hot dog.

In ***Homer's*** **frame of reference** calculate the difference between

a) the time when the front of the hot dog hits the back of Homer's mouth
b) the time when the back of the hot dog enters Homer's mouth

Does Homer succeed (i.e. does b happen before a)?

extra space for Q9:



Question 10: A space probe leaves Earth travelling at v=0.6c towards a distant planet, 15 light years away. When the probe reaches the planet, it is programmed to send a beam of protons back to the Earth. If the probe emits the protons at speed 0.8c ***in its own frame of reference***, how many years after the probe leaves Earth should people on Earth expect to receive the protons? (***4 points***)

Question 11: During its journey, the probe in the previous question sends out a light pulse every time its clock ticks (i.e every second in its frame of reference). Back on Earth, what is time between the arrival two successive light pulses from the probe? (*note: this question is only worth 1 point, so you should probably finish the others before completing it).*

scrap paper:

scrap paper:

$$\gamma = \frac{1}{\sqrt{1 - \frac{v^2}{c^2}}}$$

$$x' = \gamma(x - vt) \qquad x = \gamma(x' + vt')$$
$$t' = \gamma\left(t - \frac{v}{c^2}x\right) \qquad t = \gamma\left(t' + \frac{v}{c^2}x'\right)$$

$$u' = \frac{u - v}{1 - \frac{uv}{c^2}}$$

$$e^{i\pi} = -1$$

$$\Delta T = \frac{v^2}{c^2}\frac{L_1 + L_2}{c}$$

$$\vec{p} = \gamma m \vec{v}$$

$$f' = f\gamma\left[1 - \cos\theta \frac{v}{c}\right]$$

$$I = (\Delta x)^2 + (\Delta y)^2 + (\Delta z)^2 - (\Delta t)^2 c^2$$

$$d\tau = dt\sqrt{1 - \frac{v^2}{c^2}}$$

$$E = mc^2$$

1 light year = $c \times$ 1 year

$$-\frac{\hbar^2}{2m}\frac{\partial^2\psi}{\partial x^2} + V\psi = i\hbar\frac{\partial\psi}{\partial t}$$

$$c \approx 3 \times 10^8 \text{ m/s}$$

$$\sqrt{1 - x^2} \approx 1 - \tfrac{1}{2}x^2 \text{ for } x \ll 1 \qquad \frac{1}{\sqrt{1 - x^2}} \approx 1 + \tfrac{1}{2}x^2 \text{ for } x \ll 1$$

POSSIBLY USEFUL FORMULAE