

## *Relativity*

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1. Two spaceships, each measuring 100 m in its own rest frame, pass by each other traveling in opposite directions. Instruments on spaceship A determine that the front end of the spaceship B requires  $5.00 \times 10^{-6}$  s to traverse the full length of A.
  - a) What is the relative velocity of the two spaceships? (*ans:  $2 \times 10^7$  m/s*)
  - b) A clock in the front end of B reads exactly one o'clock as it passes by the front end of A. What will the clock read as it passes by the rear of A? (*ans: one o'clock +  $4.99 \times 10^{-6}$  s*)
  
2. Three identical radio transmitters A, B, and C, each transmitting at the frequency  $\nu_0$  in its own rest frame, are in motion as shown.
  - a) What is the frequency of B's signals as received by C? (*ans:  $\nu_0[(1 - \beta)/(1 + \beta)]^{1/2}$* )
  - b) What is the frequency of A's signals as received by C? (*ans:  $\nu_0(1 - \beta)/(1 + \beta)$* )
  
3. There is a spaceship shuttle service from Earth to Mars. Each spaceship is equipped with two identical lights, one at the front and one at the rear. The spaceships normally travel at a speed  $v_0$ , relative to Earth, such that the headlight of a spaceship approaching Earth appears green ( $\lambda = 5000 \text{ \AA}$ ) and the taillight of a departing spaceship appears red ( $\lambda = 6000 \text{ \AA}$ ). What is the value of  $v_0/c$ ? (*ans: 1/11*)
  
4. Consider three galaxies A, B, and C. An observer in A measures the velocities of C and B and finds they are moving in opposite directions each with a speed of  $0.7c$  relative to him.
  - a) What is the speed of A observed in B?
  - b) What is the speed of C observed in B?
  - c) A Calcium spectral line originating from a star in C is observed in A. What is its observed wavelength, if the same Calcium line has a measured wavelength of  $3968.49 \text{ \AA}$  in a laboratory in A.
  - d) What is the wavelength of the same spectral line, originating from a star in C, but observed in B?  
(*answers:  $0.7c$ ;  $0.94c$* )