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Student Name: \_\_\_\_\_

## Grade 12 Physics

## Class 14: Special Relativity

For questions involving relativistic speeds, please answer your questions relative to the speed of light, e.g. " $v = 0.56c$ ".

- \_\_\_\_\_ 1. Which one of the following systems would constitute an inertial reference frame?
  - (a) A weather balloon descending at constant velocity
  - (b) A rocket undergoing uniform acceleration
  - (c) A roller coaster traveling around a corkscrew turn at constant speed
  - (d) An orbiting space station
  - (e) A rotating merry-go-round
- \_\_\_\_\_ 2. Two events that are simultaneous in one frame of reference will be
  - (a) simultaneous in all frames of reference
  - (b) simultaneous in another frame that is moving in the opposite direction
  - (c) simultaneous in another frame of reference that is moving in the same direction
  - (d) simultaneous in the same frame of reference
  - (e) simultaneous in another non-inertial frame of reference
- \_\_\_\_\_ 3. An astronaut in a rocket is passing by a space station at a velocity of  $0.33c$ . Looking out the window, the astronaut sees a scientist on the space station fire a laser at a target. The laser is pointed in the same direction that the astronaut is traveling. On which of the following observations will the astronaut and scientist agree?
  - (a) The length of the rocket.
  - (b) The time it takes the laser to hit the target.
  - (c) The speed of the laser beam.
  - (d) The astronaut and scientist will not agree on any of these measurements.
- \_\_\_\_\_ 4. The headlights are shining on a truck travelling at  $100 \text{ km/h}$ . The speed of the light from the headlights relative to the road will be
  - (a)  $c + 100 \text{ km/h}$
  - (b)  $c - 100 \text{ km/h}$
  - (c)  $c$
  - (d) depends on the temperature, but faster than the speed if the truck was not moving.
  - (e) Impossible to calculate with the given information
- \_\_\_\_\_ 5. You see a horizontal metre stick moving at  $0.60c$  towards you. Its length appears to be
  - (a)  $0.60 \text{ m}$
  - (b)  $0.64 \text{ m}$
  - (c)  $0.80 \text{ m}$
  - (d)  $1.00 \text{ m}$
  - (e)  $1.25 \text{ m}$

- \_\_\_\_\_ 6. You see a vertical metre stick moving at  $0.60c$  towards you. Its length appears to be  
(a) 0.60 m  
(b) 0.64 m  
(c) 0.80 m  
(d) 1.00 m  
(e) 1.25 m
- \_\_\_\_\_ 7. An alarm clock is set to ring for a total of 1 min. It is placed on a spaceship moving at  $0.6c$ . According to Mission Control on Earth, the alarm clock rings for  
(a) 0.6 min  
(b) 0.8 min  
(c) 1 min  
(d) 1.25 min  
(e) 2 min
- \_\_\_\_\_ 8. What is proper length?  
(a) The exact length of an object in from all frames of reference.  
(b) The length of a stationary object from a moving frame of reference.  
(c) A length unit that is suitable for a given measurement.  
(d) The length of an object measured by an observer who is stationary relative to the object.
- \_\_\_\_\_ 9. An object that is 50 cm long passes an observer who measures it as 51 cm. Which statement is most likely to be correct?  
(a) The object is moving very quickly.  
(b) The object is travelling backward.  
(c) The object's length is dilated by relativity.  
(d) The observer made an error in measurement.
- \_\_\_\_\_ 10. According to the principle of conservation of mass-energy, rest energy is equivalent to which of the following?  
(a) Rest mass  
(b) Relativistic mass  
(c) Relativistic mass plus rest mass  
(d) Relativistic mass minus rest mass  
(e) Relativistic momentum
- \_\_\_\_\_ 11. Which of these effects would be felt by an astronaut travelling at a constant speed of  $0.5c$ ?  
(a) Her weight would increase.  
(b) Her height would decrease.  
(c) All of the above  
(d) None of the above

12. A spacecraft passes a spherical space station. Observers in the spacecraft measure the station's minor axis as 145 km and the major axis as 190 km.

- (a) How fast is the spacecraft travelling relative to the space station?
- (b) Why does the station not look like a sphere to the observers in the spacecraft?



13. A rocket passes by Earth at a speed of  $0.60c$ . if a person on the rocket takes 245 s to drink a cup of coffee, according to his watch, how long would that same event take according to an observer on Earth?

14. A kaon particle has a lifetime at rest in a laboratory of  $1.2 \times 10^{-8}$  s. At what speed must it travel to have its lifetime measured as  $3.6 \times 10^{-8}$  s?

15. A nuclear power reactor generates 3.00 GW of power. In one year, what is the change in the mass of the nuclear fuel to generate the energy?

16. Calculate the mass increase for a completely inelastic head-on collision of two 0.50 kg pieces of Play-Doh each moving towards the other at  $4.5 \times 10^7$  m/s in opposite direction.
17. Alpha Centauri is the nearest star system from our solar system, at about 4.2 light years from Earth, measured in the common rest frame of Earth and Alpha Centauri. Suppose you took a fast spaceship to Alpha Centauri, so it got you there in 50 years as measured on the ship. If you sent a radio message home as soon as you reached Alpha Centauri, how long after you left Earth would it arrive, according to the timekeepers on Earth?
18. Two spaceships are each 25 m long, as measured in their own rest frame. Ship A is approaching Earth at  $0.65c$ , while Ship B is approaching Earth from the opposite direction at  $0.50c$ . Find the length of B as measured in
- Earth's frame of reference
  - Ship A's frame of reference