NATIONAL OPEN UNIVERSITY OF NIGERIA
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FACULTY OF SCIENCES

DEPARTMENT OF PURE AND APPLIED SCIENCE

OCT/NOV 2019 EXAMINATIONS

**COURSE CODE:** **PHY 303**
**COURSE TITLE:** **SPECIAL RELATIVITY**
**CREDIT UNIT:** **2**
**TIME ALLOWED:** **(2 HRS)**

**INSTRUCTION:** ***Answer question 1 and any other three questions***

## QUESTION 1

(a). Suppose a supersonic airplane flies at a speed of 1,650 km/hr from Nairobi, Kenya, to Quito, Ecuador; note that this is the same speed that Earth rotates, but in the opposite direction. Describe how this flight would look to an observer on the Moon . **(4 marks)**

(b). Describe at least three pieces of evidence supporting the special theory of relativity. **(6 marks)**

(c). State the Galilean space–time transformation equations. **(2 marks)**

(d). The period of a pendulum is measured to be 3.00 s in the reference frame of the pendulum. What is the period when measured by an observer moving at a speed of 0.960c relative to the pendulum? **(6 marks)**

(e). What if the speed of the observer increases by 4.00%? Does the dilated time interval increase by 4.00%? **(7 marks)**

## QUESTION 2

(a). What is proper time? **(3 marks)**

(b). The light emitted by a galaxy contains a continuous distribution of wavelengths because the galaxy is composed of millions of stars and other thermal emitters. However, some narrow gaps occur in the continuous spectrum where the radiation has been strongly absorbed by cooler gases in the galaxy. In particular, a cloud of ionized calcium atoms produces very strong absorption at 394 nm for a galaxy at rest with respect to the Earth. For the galaxy Hydra, which is 200 million light year away, this absorption is shifted to 475 nm. How fast is Hydra moving away from the Earth? **(9 marks)**

(c). Devise an experiment you could conduct to test a prediction of special relativity. **(3 marks)**

## QUESTION 3

(a). What are the outcomes of Michelson-Morley experiment? **(5 marks)**

(b). Suppose you are driving your car on a business trip and are traveling at 30 m/s. Your boss, who is waiting at your destination, expects the trip to take 5.0 h. When you arrive late, your excuse is that the clock in your car registered the passage of 5.0 h but that you

were driving fast and so your clock ran more slowly than the clock in your boss's office. If your car clock actually did indicate a 5.0-h trip, how much time passed on your boss's clock, which was at rest on the Earth? **(5 marks)**

(c). An observer on Earth sees a spaceship at an altitude of 435 m moving downward toward the Earth at 0.970c. What is the altitude of the spaceship as measured by an observer in the spaceship? **(5 marks)**

**QUESTION 4**

(a). Differentiate between inertial and non-inertial frames of reference. **(3 marks)**

(b) A man in a boat moving at constant speed of 50km/h relative to the shore throws an object in the forward direction with a speed of 20.5km/h. What is the speed of the object as measured by an observer at rest at the shore. (**4 marks)**

(c**)** An observer at rest with respect to the ground observes a particle of mass $m_1$ = 3kg moving along the x-axis with a velocity $u_s$ =3m/s. It approaches a second particle of mass $m_2$ = 1kg moving with velocity $u_2$ =-3m/s along the same axis. After head-on collision, he finds that the velocity of $m_2$ is $u_2'$ = -3m/s along the x-axis. What are the momenta before and after the collision as seen by a moving observer walking with a velocity of 2m/s relative to the ground along the x-axis? **(8 marks)**

**QUESTION 5**

(a). State Einstein's theory of relativity. **(3 marks)**

(b). An observer on Earth sees an alien spaceship approaching at 0.60 c. The Enterprise comes to the rescue overtaking the spaceship at 0.90c relative to the alien spaceship. How fast would the observers on earth measure the Enterprise to be travelling at? **(5 marks)**

(c). A friend borrows your red "Ferrari Spaceship Model X-119" capable of travelling at 0.85c. The Ferrari is measure to be 5.6 m high and 18 m long in a stationary reference frame.

(i) How long would you say the Ferrari is as it sped by you at maximum speed?

(ii) Your friend has been gone for 2.0 h your time. How much time does he say has elapsed?

**(7 marks)**