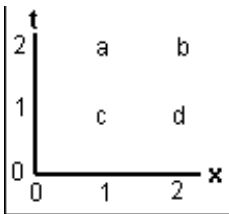




- 1 The first direct confirmation of Maxwell's electromagnetic waves involved the generation and detection of
  - a. radio waves.
  - b. sound waves.
  - c. gamma rays.
  - d. light.
  - e. X-rays.
- 2 For an object moving near the speed of light, dimensions perpendicular to its direction of motion
  - a. shrink.
  - b. stay the same.
  - c. expand.

- 3 In the following spacetime diagram, which letter is closest to the event with  $x = 1, t = 2$ ?

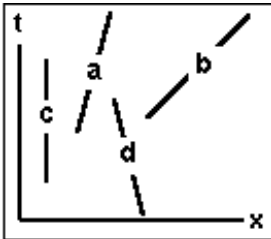


- 4 An automobile bumper jack moves the bumper up a distance of 0.01m (one centimeter) for every meter that the jack handle is moved downward. It is found that a force of 133N on the jack handle produces a lifting force of 10,000N on the bumper. What is the efficiency of this jack?
  - a. 100%.
  - b. 50%.
  - c. 75%.
  - d. 66%.
- 5 The force on a 5kg object in a gravitational field whose magnitude is  $4\text{m/s}^2$  is equal to
  - a. 5N.
  - b. 6N.
  - c. 4N.
  - d. 50N.
  - e. 20N.
- 6 A complicated system of pulleys and gears is set up so that pulling down on an "input" rope by one meter causes an "output" rope to move upward by 1/4 meter. If a force of 20 newtons is applied to the input rope, how much force can the output rope exert?
  - a. 2N.
  - b. 20N.
  - c. 80N.
  - d. 5N.

7 A 2kg rock is dropped from rest at a height of 30 meters above the ground. How much heat energy is generated when it hits the ground?

- a. 900J.
- b. 60J.
- c. 600J.
- d. 0.

8 The following spacetime diagram uses  $c=1$  units. Which is the world-line of an object moving in the positive-x direction at less than the speed of light?



9 Suppose that observers on Earth find that an asteroid collides with the planet Mars at exactly the same time that a comet collides with the earth. If a spaceship flying from Mars toward Earth observes these catastrophes, it will calculate that

- a. Mars get hit before the earth does.
- b. Earth get hit before Mars does.
- c. both happen at the same time.

10 Maxwell's theory of electromagnetism predicted that electromagnetic waves in vacuum propagate at  $3 \times 10^8$  m/s relative to

- a. a reference frame in which the usual laws of electricity and magnetism work.
- b. a reference frame in which the usual laws of mechanics work.
- c. their source.
- d. the luminiferous aether.

11 Suppose that you weigh 100lb at the surface of the earth. At one earth-radius above the surface of the earth, the force of gravity on you will be

- a. 200lb.
- b. 400lb.
- c. 50lb.
- d. 100lb.
- e. 25lb.

12 If an automobile moving at a speed of 30 miles per hour can stop in a distance of 100 feet, how much distance should it take for a car moving at 90 miles per hour to stop on the same surface?

- a. 400ft.
- b. 300ft.
- c. 900ft.
- d. 100ft.

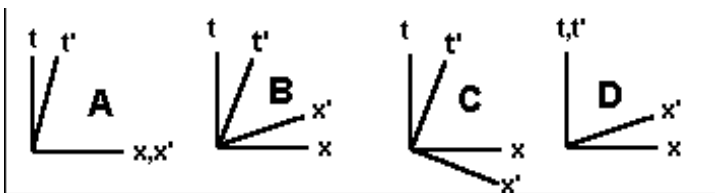
13 A clock comparison is initiated by a spaceship, which sends out the message “*This is freighter MS701. Please send GMT time-check.*”. According to the ship’s clock, the message is sent at 5:00 P.M. At 6:00 P.M. by its clock, the ship receives the message “*Read you, MS701. Phobos station time is now 5:20 P.M. GMT.*”. Freighter MS701 needs to reset its clock. Assuming that Phobos Station responded immediately (as it was programmed to do), the ship should change its clock reading from 6:00 P.M. to

- a. 5:30 P.M.
- b. 5:50 P.M.
- c. 5:20 P.M.
- d. 6:10 P.M.

14 If a moving car has 100,000J of kinetic energy, what would be the kinetic energy of a truck that is moving at the same speed but has three times the mass of the car?

- a. 100,000J.
- b. 33,333J.
- c. 300,000J.
- d. 900,000J.

15 If Einstein were to draw a spacetime diagram in which the  $x'$  and  $t'$  axes represent a moving inertial frame, which of the following diagrams would he draw?



16 The starship Enterprise is travelling on impulse drive at  $3/5$  light speed. For every two minutes that pass on board the ship, a clock back on earth will read an interval close to

- a. one minute and fifty seconds.
- b. two minutes.
- c. two minutes and ten seconds.
- d. two minutes and thirty seconds.

17 A bicycle coasts down a steep, 80 meter tall, hill. Neglecting air friction, how fast will it be going when it gets to the bottom?

- a. 1600m/s.
- b. 28m/s.
- c. 12m/s.
- d. 40m/s.

18 Electromagnetic waves propagate

- a. only where there are charged particles.
- b. only in air or water.
- c. through anything at all.
- d. through a vacuum.

- 19 The formula for kinetic energy is
- derived from Newton's Laws.
  - a definition.
  - an independent law of nature.
- 20 Which of the following phenomena consist of electromagnetic waves travelling at the speed of light?
- sound.
  - beta rays.
  - alpha rays.
  - X-rays.
- 21 In one experiment, two spheres, one with a mass of 1kg and the other with a mass of 1000kg are separated by one meter and attract each other with a tiny force. If the spheres are then replaced by one with a mass of 4kg and one with a mass of 2000kg, still one meter apart, the force between the masses will be
- the same as in the first experiment.
  - eight times the force in the first experiment.
  - twice the force in the first experiment.
  - four times the force in the first experiment.
- 22 Newton's theory of universal gravitation provided
- the first unified description of the fundamental forces of nature.
  - the first description of how objects move in the heavens.
  - the first description of how objects fall on the earth.
  - the first unified description of both the motion of objects on earth and in the heavens.
- 23 Which of the following answers is closest to the distance that an object will fall from rest in four seconds?
- 20m.
  - 80m.
  - 320m.
  - 160m.
  - 40m.
- 24 In comparison to Kepler's Laws of Planetary Motion, Newton's theory of Universal Gravitation predicted
- the same motions interpreted differently.
  - exactly the same motions.
  - a completely different set of motions.
  - almost the same motions but with corrections.

- 25 Maxwell's derivation of the speed of light from physical laws was a problem for his fellow scientists because
- The speed was not what they expected.
  - It violated velocity addition.
  - They disbelieved some steps in the derivation.
  - It violated energy conservation.
- 26 The Lorentz contraction was originally proposed as an explanation for
- the bending of light by the sun.
  - the null result of the Michelson Morely experiment.
  - the dragging of light by the aether.
  - The perihelion precession of Mercury.
- 27 In a spacetime diagram with  $t$  the time and  $x$  the distance, all of the points on the time axis have
- $t = x = 0$ .
  - $t = x$ .
  - $x = 0$ .
  - $t = 0$ .
- 28 The Michelson-Morely Experiment tested the predictions of
- Maxwell's theory of electromagnetism.
  - Einstein's theory of relativity.
  - the Aether theory of light propagation.
  - Newton's theory of mechanics.
- 29 A spaceship travels from the earth to a star that is 4 light years away. If the trip takes 5 years in earth time, how many years pass on board the ship?
- 5.
  - 4.
  - 6.
  - 3.
  - 2.
- 30 In the aether theory of light, a pulse of light travels at 186,000 miles per second relative to
- the source of the light.
  - the aether.
  - any inertial reference frame.
  - the observer of the light.

- 31 Devices that are described as “motors,” or “engines”
- a. extract energy from the aether.
  - b. destroy energy.
  - c. create energy.
  - d. convert existing energy into mechanical energy.
- 32 The photon clock that is used to derive the time dilation formula works by
- a. trapping light in a stable circular orbit.
  - b. using light to count the swings of a pendulum.
  - c. bouncing a light pulse between two mirrors.
  - d. counting photons emitted by Cesium atoms.

## Answer Key: Fall 2007 PHX3M

- 1 Choice a. (radio waves.)
- 2 Choice b. (stay the same.)
- 3 Choice a. (A)
- 4 Choice c. (75%.)
- 5 Choice e. (20N.)
- 6 Choice c. (80N.)
- 7 Choice c. (600J.)
- 8 Choice a. (A)
- 9 Choice b. (Earth get hit before Mars does.)
- 10 Choice a. (a reference frame in which the usual laws of electricity and magnetism work.)
- 11 Choice e. (25lb.)
- 12 Choice c. (900ft.)
- 13 Choice b. (5:50 P.M.)
- 14 Choice c. (300,000J.)
- 15 Choice b. (B)
- 16 Choice d. (two minutes and thirty seconds.)
- 17 Choice d. (40m/s.)
- 18 Choice d. (through a vacuum.)
- 19 Choice a. (derived from Newton's Laws.)
- 20 Choice d. (X-rays.)
- 21 Choice b. (eight times the force in the first experiment.)
- 22 Choice d. (the first unified description of both the motion of objects on earth and in the heavens.)
- 23 Choice b. (80m.)
- 24 Choice d. (almost the same motions but with corrections.)
- 25 Choice b. (It violated velocity addition.)
- 26 Choice b. (the null result of the Michelson Morely experiment.)
- 27 Choice c. ( $x = 0$ .)
- 28 Choice c. (the Aether theory of light propagation.)
- 29 Choice d. (3.)
- 30 Choice b. (the aether.)
- 31 Choice d. (convert existing energy into mechanical energy.)
- 32 Choice c. (bouncing a light pulse between two mirrors.)

## Solutions

- 1 Module r34 Electromagnetic Waves: Question 2.2
- 2 Module r40 Moving Clocks: Question 1.1
- 3 Module r38 Maps of Spacetime: Question 2.1a
- 4 Module 022 Total Energy: Question 5.1
- 5 Module g33 The Gravitational Field: Question 1.3
- 6 Module 022 Total Energy: Question 4.3
- 7 Module 022 Total Energy: Question 2.1
- 8 Module r38 Maps of Spacetime: Question 3.1b
- 9 Module r39 Map of a Moving Reference Frame: Question 4.2
- 10 Module r34 Electromagnetic Waves: Question 1.1
- 11 Module g31 Newton's Law of Universal Gravitation: Question 2.2
- 12 Module 021 Kinetic Energy: Question 4.1
- 13 Module r39 Map of a Moving Reference Frame: Question 2.1
- 14 Module 021 Kinetic Energy: Question 2.1
- 15 Module r39 Map of a Moving Reference Frame: Question 3.1b Answer = B
- 16 Module r40 Moving Clocks: Question 3.2
- 17 Module 022 Total Energy: Question 1.1
- 18 Module r34 Electromagnetic Waves: Question 3.1
- 19 Module 021 Kinetic Energy: Question 1.1
- 20 Module r34 Electromagnetic Waves: Question 4.1
- 21 Module g31 Newton's Law of Universal Gravitation: Question 1.2
- 22 Module g31 Newton's Law of Universal Gravitation: Question 3.2
- 23 Module 021 Kinetic Energy: Question 5.2
- 24 Module g31 Newton's Law of Universal Gravitation: Question 4.1
- 25 Module r35 A Problem with Relativity: Question 1.1
- 26 Module r36 Michelson-Morely Experiment: Question 2.2
- 27 Module r38 Maps of Spacetime: Question 1.1
- 28 Module r36 Michelson-Morely Experiment: Question 1.1
- 29 Module r40 Moving Clocks: Question 4.2
- 30 Module r35 A Problem with Relativity: Question 2.1
- 31 Module 022 Total Energy: Question 3.1
- 32 Module r40 Moving Clocks: Question 2.1