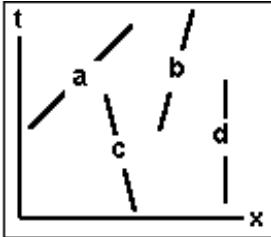




- 1 A 2kg rock is dropped from rest at a height of 30 meters above the ground. How much heat energy is generated when it hits the ground?
  - a. 600J.
  - b. 0.
  - c. 60J.
  - d. 900J.
  
- 2 A complicated system of pulleys and gears is set up so that pulling down on an “input” rope by one meter causes an “output” rope to move upward by 1/5 meter. If a force of 10 newtons is applied to the input rope, how much force can the output rope exert?
  - a. 5N.
  - b. 2N.
  - c. 10N.
  - d. 50N.
  
- 3 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 3kg and one with a mass of 2000kg, still one meter apart, the force between the masses will be
  - a. six times the force in the first experiment.
  - b. the same as in the first experiment.
  - c. twice the force in the first experiment.
  - d. three times the force in the first experiment.
  
- 4 Suppose that a car and a truck are traveling at the same speed. If the truck has three times the mass of the car, then the truck’s kinetic energy is
  - a. eight times that of the car.
  - b. three times that of the car.
  - c. four times that of the car.
  - d. nine times that of the car.
  - e. twice that of the car.
  
- 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. 20N.
  - c. 6N.
  - d. 50N.
  - e. 4N.
  
- 6 A spaceship travels from the earth to a star that is 12 light years away. If the trip takes 13 years in earth time, how many years pass on board the ship?
  - a. 6.
  - b. 5.
  - c. 3.
  - d. 4.
  - e. 2.

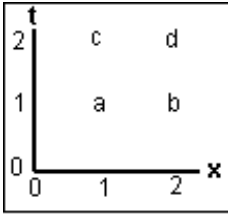
- 7 In the aether theory of light, a pulse of light travels at 186,000 miles per second relative to
- the aether.
  - any inertial reference frame.
  - the source of the light.
  - the observer of the light.

- 8 The following spacetime diagram uses  $c=1$  units. Which is the world-line of an object at rest?



- 9 Suppose that two objects, each with the same mass, are accelerated from rest to the same velocity. The force that accelerates one object is much larger than the force that accelerates the other object but acts for a shorter time. The work done by the larger force is
- equal to the work done by the smaller force.
  - larger than the work done by the smaller force.
  - smaller than the work done by the smaller force.
  - unrelated to the work done by the smaller force.
- 10 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 energy conservation.
  - They disbelieved some steps in the derivation.
  - It violated velocity addition.
- 11 According to Einstein's procedure for assigning times to distant events, if you send out a radio wave pulse at 6:00p.m. and receive an echo back at 7:00p.m., then the pulse actually hit something at
- 6:30p.m.
  - 7:00p.m.
  - 6:00p.m.
  - a time that depends on your velocity.
  - a time that depends on the target's velocity.
- 12 The first demonstration of electromagnetic wave generation used
- rapid mechanical switches.
  - charged mechanical rotors.
  - electric sparks in air.
  - vacuum tube oscillators.

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



14 Newton's theory of universal gravitation provided

- the first unified description of the fundamental forces of nature.
- 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.
- the first description of how objects move in the heavens.

15 Lorentz sought to explain the result of the Michelson-Morely experiment by asserting that the aether-wind causes changes in

- the properties of light.
- time intervals.
- lengths.
- physical laws.

16 An aircraft carrier uses a catapult to launch airplanes from its deck. The catapult consists of a hook that runs along a slot in the deck. The airplane is attached to the hook and is pulled along the slot until it reaches take-off speed. Suppose that the catapult accelerates the plane at 5 times the acceleration of gravity (5 "g"s) and the take-off speed is 100m/s. How long must the slot in the deck be?

- 1000m.
- 1m.
- 10m.
- 100m.
- 200m.

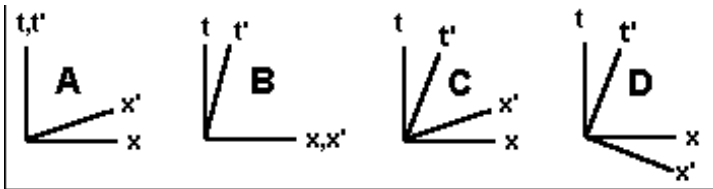
17 In comparison to Kepler's Laws of Planetary Motion, Newton's theory of Universal Gravitation predicted

- the same motions interpreted differently.
- exactly the same motions.
- almost the same motions but with corrections.
- a completely different set of motions.

- 18 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?
- 66%.
  - 50%.
  - 100%.
  - 75%.
- 19 In a spacetime diagram with  $t$  the time and  $x$  the distance, all of the points on the space axis have
- $x = 0$ .
  - $t = x$ .
  - $t = x = 0$ .
  - $t = 0$ .
- 20 The Michelson-Morely Experiment tested the predictions of
- Newton's theory of mechanics.
  - the Aether theory of light propagation.
  - Maxwell's theory of electromagnetism.
  - Einstein's theory of relativity.
- 21 If the earth were compressed to the size of the moon — a factor of four in radius — with no change in its mass, the weight of a 100kg object on its surface would then be
- 1000N.
  - 250N.
  - 4000N.
  - 125N.
  - 16000N.
- 22 The space between the stars is not quite empty. It contains faint traces of gas as well as charged particles. If this interstellar medium were removed, the light from the stars
- would reach us only from stars emitting stellar winds.
  - would still reach us.
  - would no longer reach us.
- 23 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 Earth toward Mars observes these catastrophes, it will calculate that
- Mars get hit before the earth does.
  - both happen at the same time.
  - Earth get hit before Mars does.

- 24 Two spaceships fly side by side at nearly the speed of light, separated by a distance of 186,000 miles (one light-second in other words) in their own reference frame. If radio messages are exchanged between the ships the clocks on board the ships will find that each exchange is delayed by a round-trip travel time of
- 2s.
  - less than 2s.
  - more than 2s.
  - an indeterminate amount of time.
- 25 If the speed of an automobile increases by a factor of two, the distance that it takes to stop should increase by a factor of
- 4.
  - 16.
  - 9.
  - 2.
  - 3.
- 26 An electrical power plant
- destroys energy.
  - creates energy.
  - converts energy.
- 27 A pendulum consists of a lead ball attached to one end of a string that is 1.25m long. The other end of the string is attached to a hook fixed in the ceiling. The pendulum is started by lifting the ball until the string is horizontal and the ball is against the ceiling. Which of the following answers is closest to the speed of the ball when it gets to the low point of its swing?
- 8m/s.
  - 25m/s.
  - 5m/s.
  - 6m/s.
  - 3.5m/s.
- 28 Two spaceships travel, side-by-side, at nearly the speed of light (relative to the earth). Each ship sees the other just 0.1 light-years away in a direction perpendicular to their direction of motion. Each ship leaves a thin trail of gas as it travels. In a frame of reference at rest relative to the earth, the distance between the two gas trails will be
- more than 0.1 light years.
  - 0.1 light years.
  - less than 0.1 light years.
- 29 Which of the following phenomena consist of electromagnetic waves travelling at the speed of light?
- gamma radiation
  - gravity waves.
  - alpha rays.
  - beta rays.

- 30 A rogue star is observed to be headed directly for our sun. The expected collision will cause a supernova explosion with an initial flare of electromagnetic radiation capable of destroying everything in its path. Before the collision occurs, you get into a spaceship and speed away at 185,000 miles per second (relative to the sun). As you race away from the sun, the predicted supernova explosion occurs and sends its initial flare after you at 186,000 miles per second (relative to the former sun). As each second passes inside the ship, the distance between you and the flare closes (relative to the ship) by
- a. 1000 miles.
  - b. 186,000 miles.
  - c. 185,000 miles.
  - d. 2000 miles.
  - e. 187,000 miles.
- 31 The starship Enterprise is travelling on impulse drive at  $4/5$  light speed. For every two minutes that pass on board the ship, a clock back on earth will read an interval close to
- a. two minutes and thirty seconds.
  - b. two minutes and ten seconds.
  - c. three minutes and twenty seconds.
  - d. two minutes.
- 32 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?



## Answer Key: Fall 2007 PHX3B

- 1 Choice a. (600J.)
- 2 Choice d. (50N.)
- 3 Choice a. (six times the force in the first experiment.)
- 4 Choice b. (three times that of the car.)
- 5 Choice b. (20N.)
- 6 Choice b. (5.)
- 7 Choice a. (the aether.)
- 8 Choice d. (D)
- 9 Choice a. (equal to the work done by the smaller force.)
- 10 Choice d. (It violated velocity addition.)
- 11 Choice a. (6:30p.m.)
- 12 Choice c. (electric sparks in air.)
- 13 Choice b. (B)
- 14 Choice c. (the first unified description of both the motion of objects on earth and in the heavens.)
- 15 Choice c. (lengths.)
- 16 Choice d. (100m.)
- 17 Choice c. (almost the same motions but with corrections.)
- 18 Choice d. (75%.)
- 19 Choice d. ( $t = 0$ .)
- 20 Choice b. (the Aether theory of light propagation.)
- 21 Choice e. (16000N.)
- 22 Choice b. (would still reach us.)
- 23 Choice a. (Mars get hit before the earth does.)
- 24 Choice a. (2s.)
- 25 Choice a. (4.)
- 26 Choice c. (converts energy.)
- 27 Choice c. (5m/s. )
- 28 Choice b. (0.1 light years.)
- 29 Choice a. (gamma radiation)
- 30 Choice b. (186,000 miles.)
- 31 Choice c. (three minutes and twenty seconds.)
- 32 Choice c. (C)

## Solutions

- 1 Module 022 Total Energy: Question 2.1
- 2 Module 022 Total Energy: Question 4.2
- 3 Module g31 Newton's Law of Universal Gravitation: Question 1.1
- 4 Module 021 Kinetic Energy: Question 2.2
- 5 Module g33 The Gravitational Field: Question 1.3
- 6 Module r40 Moving Clocks: Question 4.4
- 7 Module r35 A Problem with Relativity: Question 2.1
- 8 Module r38 Maps of Spacetime: Question 3.3c
- 9 Module 021 Kinetic Energy: Question 1.3
- 10 Module r35 A Problem with Relativity: Question 1.1
- 11 Module r39 Map of a Moving Reference Frame: Question 2.2
- 12 Module r34 Electromagnetic Waves: Question 2.1
- 13 Module r38 Maps of Spacetime: Question 2.2b
- 14 Module g31 Newton's Law of Universal Gravitation: Question 3.2
- 15 Module r36 Michelson-Morely Experiment: Question 2.1
- 16 Module 021 Kinetic Energy: Question 5.4
- 17 Module g31 Newton's Law of Universal Gravitation: Question 4.1
- 18 Module 022 Total Energy: Question 5.1
- 19 Module r38 Maps of Spacetime: Question 1.2
- 20 Module r36 Michelson-Morely Experiment: Question 1.1
- 21 Module g31 Newton's Law of Universal Gravitation: Question 2.3
- 22 Module r34 Electromagnetic Waves: Question 3.2
- 23 Module r39 Map of a Moving Reference Frame: Question 4.1
- 24 Module r40 Moving Clocks: Question 2.2
- 25 Module 021 Kinetic Energy: Question 4.2
- 26 Module 022 Total Energy: Question 3.2
- 27 Module 022 Total Energy: Question 1.6
- 28 Module r40 Moving Clocks: Question 1.2
- 29 Module r34 Electromagnetic Waves: Question 4.2
- 30 Module r34 Electromagnetic Waves: Question 1.2
- 31 Module r40 Moving Clocks: Question 3.3
- 32 Module r39 Map of a Moving Reference Frame: Question 3.1a Answer = C