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 4m/s² 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
   a. derived from Newton’s Laws.
   b. a definition.
   c. an independent law of nature.

20 Which of the following phenomena consist of electromagnetic waves travelling at the speed of light?
   a. sound.
   b. beta rays.
   c. alpha rays.
   d. 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
   a. the same as in the first experiment.
   b. eight times the force in the first experiment.
   c. twice the force in the first experiment.
   d. four times the force in the first experiment.

22 Newton’s theory of universal gravitation provided
   a. the first unified description of the fundamental forces of nature.
   b. the first description of how objects move in the heavens.
   c. the first description of how objects fall on the earth.
   d. 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?
   a. 20m.
   b. 80m.
   c. 320m.
   d. 160m.
   e. 40m.

24 In comparison to Kepler’s Laws of Planetary Motion, Newton’s theory of Universal Gravitation predicted
   a. the same motions interpreted differently.
   b. exactly the same motions.
   c. a completely different set of motions.
   d. 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
   a. The speed was not what they expected.
   b. It violated velocity addition.
   c. They disbelieved some steps in the derivation.
   d. It violated energy conservation.

26 The Lorentz contraction was originally proposed as an explanation for
   a. the bending of light by the sun.
   b. the null result of the Michelson Morely experiment.
   c. the dragging of light by the aether.
   d. 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
   a. $t = x = 0$.
   b. $t = x$.
   c. $x = 0$.
   d. $t = 0$.

28 The Michelson-Morely Experiment tested the predictions of
   a. Maxwell’s theory of electromagnetism.
   b. Einstein’s theory of relativity.
   c. the Aether theory of light propagation.
   d. 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?
   a. 5.
   b. 4.
   c. 6.
   d. 3.
   e. 2.

30 In the aether theory of light, a pulse of light travels at 186,000 miles per second relative to
   a. the source of the light.
   b. the aether.
   c. any inertial reference frame.
   d. 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
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