1 Maxwell's derivation of the speed of light from physical laws was a problem for his fellow scientists because

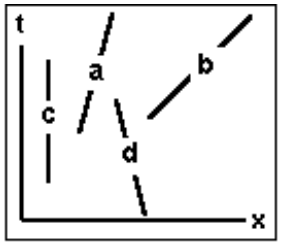
a. It violated energy conservation.

b. They disbelieved some steps in the derivation.

c. It violated velocity addition.

d. The speed was not what they expected.

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



3 The photon clock that is used to derive the time dilation formula works by

a. using light to count the swings of a pendulum.

b. bouncing a light pulse between two mirrors.

c. trapping light in a stable circular orbit.

d. counting photons emitted by Cesium atoms.

4 Newton's theory of universal gravitation provided

a. the first description of how objects move in the heavens.

b. the first unified description of the fundamental forces of nature.

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.

5 If Einstein were to draw a spacetime diagram in which the x and t axes represent the rest frame and the x' and t' axes represent a moving inertial frame, he would draw

a. the x'-axis different from the x-axis but the t'-axis the same as the t-axis.

b. the x'-axis different from the x-axis and the t'-axis different from the t-axis.

c. the x'-axis the same as the x-axis and the t'-axis the same as the t-axis.

d. the x'-axis the same as the x-axis but the t'-axis different from the t-axis.

6 A hoist for pulling engines out of cars consists of a large metal box with two chains hanging down from it. You can't see inside the box, so you have no idea what is in there. However, you notice that when you pull one chain down by two meters, the other chain goes up by one tenth of a meter. If the maximum force that you can exert on one of these chains is 1000N, what is the maximum weight that you could possibly lift with this hoist?

a. 2000N.

b. $10,000$N.

c. 1000N.

d. $20,000$N.

e. There is no way to tell.

7 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. nine times that of the car.

c. four times that of the car.

d. twice that of the car.

e. three times that of the car.

8 An airplane is forced to make a wheels-up landing on a concrete runway. The pilot touches down as gently as possible at a speed of 100m/s and the plane slides to a stop, sending sparks showering in all directions. If the mass of the plane is $10,000$kg, how much heat energy is deposited in the runway and the bottom of the plane during the slide?

a. $50,000,000$J.

b. $10,000$J.

c. $1,000,000$J.

d. $100,000,000$J.

e. $500,000$J.

9 Devices that are described as "motors," or "engines"

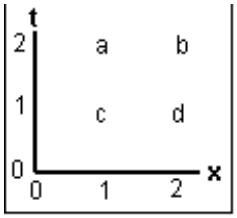
a. convert existing energy into mechanical energy.

b. create energy.

c. destroy energy.

d. extract energy from the aether.

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



11 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 observer of the light.

c. the aether.

d. any inertial reference frame.

12 The first direct confirmation of Maxwell's electromagnetic waves involved the generation and detection of

a. radio waves.

b. sound waves.

c. light.

d. X-rays.

e. gamma rays.

13 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

a. 250N.

b. 16000N.

c. 1000N.

d. 125N.

e. 4000N.

14 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. two minutes and ten seconds.

b. two minutes and thirty seconds.

c. one minute and fifty seconds.

d. two minutes.

15 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. 12m/s.

b. 28m/s.

c. 40m/s.

d. 1600m/s.

16 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

a. would still reach us.

b. would reach us only from stars emitting stellar winds.

c. would no longer reach us.

17 A clock comparison is initiated by a spaceship, which sends out a message at 2:00 P.M. (by the ship's clock). At 6:00 P.M. by its clock, the ship receives the message *"Phobos station time is now 4:30 P.M. GMT"*. Assuming that Phobos Station responded immediately, the ship should change its clock reading from 6:00 P.M. to

a. 5:30 P.M.

b. 6:30 P.M.

c. 6:20 P.M.

d. 6:10 P.M.

18 If an automobile moving at a speed of 20 miles per hour can stop in a distance of 50 feet, how much distance should it take for a car moving at 40 miles per hour to stop on the same surface?

a. 300ft.

b. 900ft.

c. 100ft.

d. 50ft.

e. 200ft.

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

a. their source.

b. a reference frame in which the usual laws of mechanics work.

c. a reference frame in which the usual laws of electricity and magnetism work.

d. the luminiferous aether.

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

a. the same motions interpreted differently.

b. a completely different set of motions.

c. exactly the same motions.

d. almost the same motions but with corrections.

21 A lever has an input arm that is 2m long and an output arm that is 0.1m long. The lever pivots on an extremely rusty hinge, so its mechanical efficiency is only 50%. Pushing down on the input arm with a force of 10 newtons will yield a force at the output arm of

a. 200N.

b. 20N.

c. 100N.

d. 10N.

22 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. the same as in the first experiment.

b. six times the force in the first experiment.

c. twice the force in the first experiment.

d. three times the force in the first experiment.

23 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

a. less than 0.1 light years.

b. 0.1 light years.

c. more than 0.1 light years.

24 The force on a 3kg object in a gravitational field whose magnitude is $12 m/s^2$ is equal to

a. 3N.

b. 36N.

c. 12N.

d. 4N.

e. 30N.

25 The Michelson-Morely Experiment tested the predictions of

a. Maxwell's theory of electromagnetism.

b. the Aether theory of light propagation.

c. Einstein's theory of relativity.

d. Newton's theory of mechanics.

26 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?

a. 10m.

b. 1000m.

c. 100m.

d. 200m.

e. 1m.

27 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

a. Earth get hit before Mars does.

b. Mars get hit before the earth does.

c. both happen at the same time.

28 Which of the following phenomena consist of electromagnetic waves travelling at the speed of light?

a. gamma radiation

b. beta rays.

c. gravity waves.

d. alpha rays.

29 The Lorentz contraction was originally proposed as an explanation for

a. The perihelion precession of Mercury.

b. the null result of the Michelson Morely experiment.

c. the dragging of light by the aether.

d. the bending of light by the sun.

30 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. 6.

b. 5.

c. 4.

d. 3.

e. 2.

31 In a spacetime diagram with t the time and x the distance, all of the points on the space axis have

a. $t = 0$.

b. $t = x = 0$.

c. $x = 0$.

d. $t = x$.

32 The formula for kinetic energy is

a. an independent law of nature.

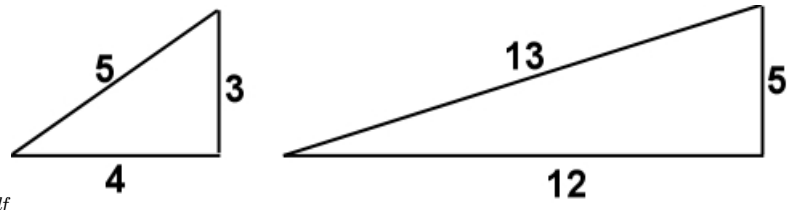
b. a definition.

c. derived from Newton's Laws.

Useful Formulas

$p = mv$	$W = F_d d = F d_F$	$F = ma$
K.E.$_{\text{Newton}} = \frac{1}{2}mv^2$	P.E. $= mgh$	$W = mg$
$v = at$	$v^2 = 2ad$	$d = \frac{1}{2}at^2$
$v_{\text{average}} = \frac{d}{t}$	Eff $= \frac{\text{Work out}}{\text{Work in}}$	$F = G\frac{mM}{D^2}$
$t_{\text{earth}} = \frac{T_{\text{ship}}}{\sqrt{1-v^2}}$	${T_{\text{ship}}}^2 = {t_{\text{earth}}}^2 - {x_{\text{earth}}}^2$	

Integer right triangles:
triangles



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Key: PHX3P1 Fall 2004

1 Choice c. (It violated velocity addition.)

2 Choice c. (C)

3 Choice b. (bouncing a light pulse between two mirrors.)

4 Choice d. (the first unified description of both the motion of objects on earth and in the heavens.)

5 Choice b. (the x'-axis different from the x-axis and the t'-axis different from the t-axis.)

6 Choice d. ($20,000$N.)

7 Choice e. (three times that of the car.)

8 Choice a. ($50,000,000$J.)

9 Choice a. (convert existing energy into mechanical energy.)

10 Choice d. (D)

11 Choice c. (the aether.)

12 Choice a. (radio waves.)

13 Choice b. (16000N.)

14 Choice b. (two minutes and thirty seconds.)

15 Choice c. (40m/s.)

16 Choice a. (would still reach us.)

17 Choice b. (6:30 P.M.)

18 Choice e. (200ft.)

19 Choice c. (a reference frame in which the usual laws of electricity and magnetism work.)

20 Choice d. (almost the same motions but with corrections.)

21 Choice c. (100N.)

22 Choice b. (six times the force in the first experiment.)

23 Choice b. (0.1 light years.)

24 Choice b. (36N.)

25 Choice b. (the Aether theory of light propagation.)

26 Choice c. (100m.)

27 Choice b. (Mars get hit before the earth does.)

28 Choice a. (gamma radiation)

29 Choice b. (the null result of the Michelson Morely experiment.)

30 Choice d. (3.)

31 Choice a. ($t = 0$.)

32 Choice c. (derived from Newton's Laws.)

Where to find things in the notes

1 Module r35 A Problem with Relativity: Question 1.1
2 Module r38 Maps of Spacetime: Question 3.3b
3 Module r40 Moving Clocks: Question 2.1
4 Module g31 Newton's Law of Universal Gravitation: Question 3.2
5 Module r39 Map of a Moving Reference Frame: Question 3.2
6 Module 022 Total Energy: Question 4.1
7 Module 021 Kinetic Energy: Question 2.2
8 Module 022 Total Energy: Question 2.2
9 Module 022 Total Energy: Question 3.1
10 Module r38 Maps of Spacetime: Question 2.2a
11 Module r35 A Problem with Relativity: Question 2.1
12 Module r34 Electromagnetic Waves: Question 2.2
13 Module g31 Newton's Law of Universal Gravitation: Question 2.3
14 Module r40 Moving Clocks: Question 3.2
15 Module 022 Total Energy: Question 1.1
16 Module r34 Electromagnetic Waves: Question 3.2
17 Module r39 Map of a Moving Reference Frame: Question 2.3
18 Module 021 Kinetic Energy: Question 4.4
19 Module r34 Electromagnetic Waves: Question 1.1
20 Module g31 Newton's Law of Universal Gravitation: Question 4.1
21 Module 022 Total Energy: Question 5.3
22 Module g31 Newton's Law of Universal Gravitation: Question 1.1
23 Module r40 Moving Clocks: Question 1.2
24 Module g33 The Gravitational Field: Question 1.2
25 Module r36 Michelson-Morely Experiment: Question 1.1
26 Module 021 Kinetic Energy: Question 5.4
27 Module r39 Map of a Moving Reference Frame: Question 4.1
28 Module r34 Electromagnetic Waves: Question 4.2
29 Module r36 Michelson-Morely Experiment: Question 2.2
30 Module r40 Moving Clocks: Question 4.2
31 Module r38 Maps of Spacetime: Question 1.2
32 Module 021 Kinetic Energy: Question 1.1