1   In a gravitational field of magnitude $12m/s^2$, the force on an object of mass 4kg is equal to

     a. 48N.

     b. 4N.

     c. 12N.

     d. 16N.

     e. 3N.

2   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. 3.

     b. 2.

     c. 4.

     d. 6.

     e. 5.

3   The Michelson-Morely Experiment tested the predictions of

     a. the Aether theory of light propagation.

     b. Maxwell's theory of electromagnetism.

     c. Newton's theory of mechanics.

     d. Einstein's theory of relativity.

4   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. 60J.

     b. 600J.

     c. 0.

     d. 900J.

5   An electrical power plant

     a. converts energy.

     b. creates energy.

     c. destroys energy.

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

     a. almost the same motions but with corrections.

     b. the same motions interpreted differently.

     c. exactly the same motions.

     d. a completely different set of motions.

7   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

     a. 3.

     b. 4.

     c. 16.

     d. 9.

     e. 2.

8   The formula for kinetic energy is

     a. derived from Newton's Laws.

     b. a definition.

     c. an independent law of nature.

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 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.

10   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. 100m.

     b. 200m.

     c. 10m.

     d. 1m.

     e. 1000m.

11   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. 6:10 P.M.

     c. 6:20 P.M.

     d. 6:30 P.M.

12 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 $10,000$N on the bumper. What is the efficiency of this jack?

   a. 100%.

   b. 50%.

   c. 75%.

   d. 66%.

13 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. 1000N.

   b. 2000N.

   c. $10,000$N.

   d. $20,000$N.

   e. There is no way to tell.

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

   a. light.

   b. radio waves.

   c. gamma rays.

   d. X-rays.

   e. sound waves.

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

   a. beta rays.

   b. gravity waves.

   c. gamma radiation

   d. alpha rays.

16 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 3000kg, still one meter apart, the force between the masses will be

   a. the same as in the first experiment.

   b. three times the force in the first experiment.

   c. twelve times the force in the first experiment.

   d. four times the force in the first experiment.

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

   a. $t = x$.

   b. $x = 0$.

   c. $t = 0$.

   d. $t = x = 0$.

18 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. three minutes and twenty seconds.

   b. two minutes and ten seconds.

   c. two minutes and thirty seconds.

   d. two minutes.

19 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. nine times that of the car.

   b. three times that of the car.

   c. eight times that of the car.

   d. four times that of the car.

   e. twice that of the car.

20 For an object moving near the speed of light, dimensions perpendicular to its direction of motion

   a. stay the same.

   b. expand.

   c. shrink.

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

   a. They disbelieved some steps in the derivation.

   b. The speed was not what they expected.

   c. It violated velocity addition.

   d. It violated energy conservation.

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

   a. counting photons emitted by Cesium atoms.

   b. bouncing a light pulse between two mirrors.

   c. trapping light in a stable circular orbit.

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

23 In the aether theory of light, a pulse of light travels at 186,000 miles per second relative to

    a. the observer of the light.

    b. the source of the light.

    c. the aether.

    d. any inertial reference frame.

24 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. 12m/s.

    c. 28m/s.

    d. 40m/s.

25 Suppose that the distance between two objects is increased from 2m to 20m. The force of gravitational attraction between the objects will then be multiplied by a factor of

    a. 1/100.

    b. 1/10.

    c. 100.

    d. 10.

    e. 1/2.

26 The unification of our understanding of heavenly motions with the motions of earthly objects was achieved by

    a. Halley.

    b. Newton.

    c. Kepler.

    d. Galileo.

27 Electromagnetic waves propagate

    a. only in air or water.

    b. only where there are charged particles.

    c. through a vacuum.

    d. through anything at all.

28 The Lorentz contraction was originally proposed as an explanation for

    a. The perihelion precession of Mercury.

    b. the bending of light by the sun.

    c. the null result of the Michelson Morely experiment.

   d. the dragging of light by the aether.

29 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. 187,000 miles.

    b. 1000 miles.

    c. 2000 miles.

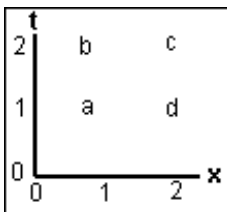   d. 185,000 miles.

    e. 186,000 miles.

30 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?
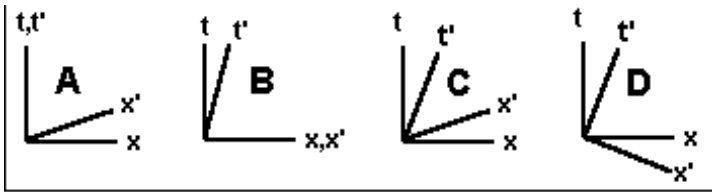
31 The following spacetime diagram uses c=1 units. Which is the world-line of an object at rest?
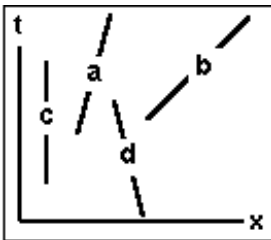
32 In the following spacetime diagram, which letter is closest to the event with x = 2, t = 1?

Useful Formulas

$$p = mv \qquad\qquad W = F_d d = F d_F \qquad\qquad F = ma$$

$$\text{K.E.}_{\text{Newton}} = \tfrac{1}{2}mv^2 \qquad\qquad \text{P.E.} = mgh \qquad\qquad W = mg$$

$$v = at \qquad\qquad v^2 = 2ad \qquad\qquad d = \tfrac{1}{2}at^2$$
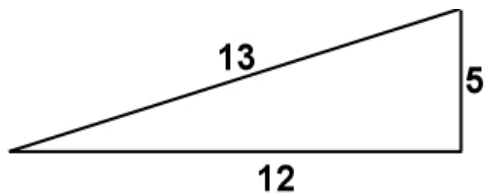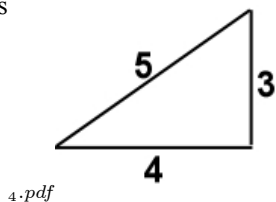
$$v_{\text{average}} = \tfrac{d}{t} \qquad\qquad \text{Eff} = \tfrac{\text{Work out}}{\text{Work in}} \qquad\qquad F = G\tfrac{mM}{D^2}$$

$$t_{\text{earth}} = \tfrac{T_{\text{ship}}}{\sqrt{1-v^2}} \qquad\qquad T_{\text{ship}}{}^2 = t_{\text{earth}}{}^2 - x_{\text{earth}}{}^2$$

Integer right triangles:
triangles

$5 \quad 3 \quad 4$

$13 \quad 5 \quad 12$

$_4 .pdf$

Key: PHX3P2

```
 1 Choice a.  (48N.)
 2 Choice a.  (3.)
 3 Choice a.  (the Aether theory of light propagation.)
 4 Choice b.  (600J.)
 5 Choice a.  (converts energy.)
 6 Choice a.  (almost the same motions but with corrections.)
 7 Choice b.  (4.)
 8 Choice a.  (derived from Newton's Laws.)
 9 Choice b.  (Mars get hit before the earth does.)
10 Choice a.  (100m.)
11 Choice d.  (6:30 P.M.)
12 Choice c.  (75%.)
13 Choice d.  (20,000N.)
14 Choice b.  (radio waves.)
15 Choice c.  (gamma radiation)
16 Choice c.  (twelve times the force in the first experiment.)
17 Choice c.  ($t = 0$.)
18 Choice a.  (three minutes and twenty seconds.)
19 Choice b.  (three times that of the car.)
20 Choice a.  (stay the same.)
21 Choice c.  (It violated velocity addition.)
22 Choice b.  (bouncing a light pulse between two mirrors.)
23 Choice c.  (the aether.)
24 Choice d.  (40m/s.)
25 Choice a.  (1/100.)
26 Choice b.  (Newton.)
27 Choice c.  (through a vacuum.)
28 Choice c.  (the null result of the Michelson Morely experiment.)
29 Choice e.  (186,000 miles.)
30 Choice c.  (C)
31 Choice c.  (C)
32 Choice d.  (D)
```

Where to look for things in the notes

1 Module g33 The Gravitational Field: Question 1.4

2 Module r40 Moving Clocks: Question 4.2

3 Module r36 Michelson-Morely Experiment: Question 1.1

4 Module 022 Total Energy: Question 2.1

5 Module 022 Total Energy: Question 3.2

6 Module g31 Newton's Law of Universal Gravitation: Question 4.1

7 Module 021 Kinetic Energy: Question 4.2

8 Module 021 Kinetic Energy: Question 1.1

9 Module r39 Map of a Moving Reference Frame: Question 4.1

10 Module 021 Kinetic Energy: Question 5.4

11 Module r39 Map of a Moving Reference Frame: Question 2.3

12 Module 022 Total Energy: Question 5.1

13 Module 022 Total Energy: Question 4.1

14 Module r34 Electromagnetic Waves: Question 2.2

15 Module r34 Electromagnetic Waves: Question 4.2

16 Module g31 Newton's Law of Universal Gravitation: Question 1.3

17 Module r38 Maps of Spacetime: Question 1.2

18 Module r40 Moving Clocks: Question 3.3

19 Module 021 Kinetic Energy: Question 2.2

20 Module r40 Moving Clocks: Question 1.1

21 Module r35 A Problem with Relativity: Question 1.1

22 Module r40 Moving Clocks: Question 2.1

23 Module r35 A Problem with Relativity: Question 2.1

24 Module 022 Total Energy: Question 1.1

25 Module g31 Newton's Law of Universal Gravitation: Question 2.4

26 Module g31 Newton's Law of Universal Gravitation: Question 3.1

27 Module r34 Electromagnetic Waves: Question 3.1

28 Module r36 Michelson-Morely Experiment: Question 2.2

29 Module r34 Electromagnetic Waves: Question 1.2

30 Module r39 Map of a Moving Reference Frame: Question 3.1a Answer = C

31 Module r38 Maps of Spacetime: Question 3.3b

32 Module r38 Maps of Spacetime: Question 2.2c