1 (Astronomical note: In this part of the world, the sun rises in the east, moves across the southern sky, and sets in the west.) It has just stopped raining and you see a rainbow that is a full half-circle in the eastern sky. What time is it?

a. 6:00 am.

b. 3:00 pm.

c. 6:00 pm.

d. 9:00 am.

2 A man pushes on a railroad car with a force of 100N for ten seconds. The car does not move (the brakes are on). The work that the man does on the railroad car is

a. 100J.

b. $10,000$J.

c. 1000J.

d. 0J.

3 It is the year 2060 and you are participating in the 30th annual lunar skeet shoot. As a clay pigeon comes flying up from behind one of the moon's craters, you trigger your computerized magnetic rifle and let fly with an iron slug. Since there is no air on the moon, you can count on the uncomplicated laws of projectile motion that you learned in physics class. Your rifle is aimed by a computer that is designed to operate in open space where there is no gravity to contend with. Thus it aims at a point ahead of the pigeon where a straight-line path would predict it to be when the slug arrives. The computer does not take the moon's gravity into account and does not know that the pigeon is actually following a curved trajectory.

a. you hit the pigeon anyway.

b. your slug always flies above the pigeon.

c. your slug always flies below the pigeon.

4 Which of the following statements is scientific (as defined by Popper)?

a. There is intelligent life on other stars.

b. There is no such thing as a free lunch.

c. There is beauty in a sunset.

5 If an object accelerates from rest at the constant rate of $10\,\mathrm{m/s^2}$, what will be its velocity after three seconds?

a. $180\,\mathrm{m/s}$.

b. $30\,\mathrm{m/s}$.

c. $10\,\mathrm{m/s}$.

d. $60\,\mathrm{m/s}$.

6 If a particle whose rest-mass-energy is 1 Mev travels at 5/13 the speed of light, its kinetic energy is

a. $(2/3)$Mev.

b. $(1/12)$Mev.

c. $(8/5)$Mev.

d. $(1/13)$Mev.

7 A voltage drop of 4V causes 5A of current to flow through a light bulb. Assuming that Ohm's Law applies here, what voltage drop would cause a current of 30A to flow through the bulb?

a. 20V.

b. 9V.

c. 6V.

d. 5V.

e. 24V.

8 The eye adapts to changing light intensity by

a. modifying its cornea.

b. opening and closing its pupil.

c. lengthening and shortening the eyeball.

d. stretching and relaxing its lens.

9 Orbital velocity — 8000m/s — is a tiny fraction of the speed of light. In particular, it corresponds to $v/c = 2.67 \times 10^{-5}$. The quantity that occurs in the time dilation formula is even smaller, $(v/c)^2 = 7.13 \times 10^{-10}$. When highly accurate clocks are placed aboard earth satellites and compared to clocks on earth, the time dilation effect

a. has been observed but is too small to be of practical importance.

b. is inherently unobservable.

c. is much too small to observe with current technology.

d. is large enough to sometimes be of practical importance.

10 The acceleration of an object is defined to be the rate of change of the object's

a. upward velocity component.

b. velocity vector.

c. position.

d. speed.

e. altitude.

11 In which of the following situations would an automobile be in equilibrium?

a. Accelerating away from a stop light.

b. Moving at constant speed down a long straight incline.

c. Accelerating down a long straight incline.

d. Moving at constant speed in a circle.

e. Moving at constant speed over the top of a hill.

12 Two twins in twin spaceships separate at 99% of the speed of light. When they separate, they are each 20 years old. They have agreed that one of them will turn around after one year of travel and fly back to rejoin the other. If the one who turns around is 22 years old when they get back together, the other twin will be

a. also 22 years old.

b. either older or younger than 22, there is no way to tell.

c. more than 22 years old.

d. less than 22 years old.

13 Mean Manfred is standing watch in the crow's nest of a tall sailing ship. He gets that duty a lot because everyone feels much safer with him as far away as possible. Also he smells bad. Old MM has already tried dropping lead sinkers on fellow crewman on the deck below. The captain told him that he would be shot if he tried that again. This time, a thoroughly bored Mean Manfred decides to engage in a game of "dolphin bonking". The dolphins swim beside the ship because they like to play in the bow wave. As the ship rocks back and forth, the crow's nest sways out over one side of the ship and then out over the other. When MM finds himself directly over a dolphin, he drops a lead sinker. The ship is under full sail and plowing along at 20 knots. By the time the lead sinker reaches the water level,

a. the falling sinker leaves the ship and dolphin behind and lands ahead of the dolphin.

b. it is still directly over the dolphin and hits the poor creature.

c. the ship and the swimming dolphin have left the falling sinker behind and it misses the dolphin.

14 Electromagnetic waves propagate

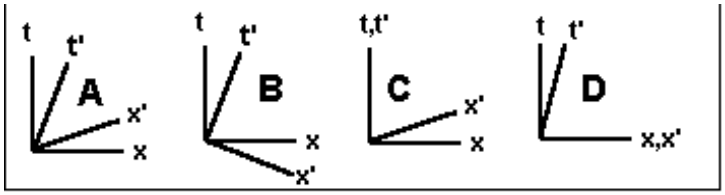
a. only in air or water.

b. through a vacuum.

c. through anything at all.

d. only where there are charged particles.

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 A far-sighted person, someone who has trouble focusing on nearby objects, needs to wear glasses with

a. barrel-shaped lenses.

b. diverging lenses.

c. flat lenses.

d. converging lenses.

17 An electrical power plant

a. destroys energy.

b. creates energy.

c. converts energy.

18 A jet plane travels 5000 miles in 10 hours. Its speed is

a. 5000mi/ hr.

b. $1/500$hr/mi.

c. $1/10$hr/mi.

d. 10mi/ hr.

e. 500mi/hr.

19 Suppose that you are pushing a large packing crate along a tile floor. You had to exert a force to start the box moving. Compared to this force, the force that you must exert to keep the box sliding along the floor is

a. smaller.

b. the same.

c. larger.

20 The aether theory modified electromagnetism so that the usual laws of electricity and magnetism would hold

a. only in the universal rest frame.

b. only in inertial frames at rest relative to the earth.

c. in all inertial frames.

d. only in inertial frames at rest relative to the aether.

21 A pair of electrically charged objects repel each other with a force of 144 Newton when they are a distance of 2m apart. If their charges stay the same, what will be the repulsive force between them when they are 6m apart?

a. 48N.

b. 16N.

c. 9N.

d. 144N.

22 The speed of light is 3×10^8m/s. How much energy is released when the mass of a system decreases by one microgram (10^{-9}kg)?.

a. 9×10^{13}J.

b. 9×10^{10}J.

c. 9×10^{7}J.

d. 0.3J

e. 9×10^{16}J.

23 If the electric field everywhere near a particular point in space points toward that point, it follows that

a. there is no charge at that point.

b. there is a negative charge at that point.

c. there is a dipole at that point.

d. there is a positive charge at that point.

24 Light that strikes a mirror at a 60 degree angle of incidence will reflect at an angle to the perpendicular of

a. 90 degrees.

b. 30 degrees.

c. 60 degrees.

d. 45 degrees.

25 A baseball pitcher acquires an unbalanced electrical charge by scuffing his feet in the dirt and transfers -0.0001C to a baseball as he throws it toward home plate. A thunderstorm is brewing and there is a vertical electric field of 10,000N/C *pointing straight down*. The electrical force on the baseball is

a. 1N upward.

b. 1N downward.

c. 0.1N upward.

d. 0.1N downward.

26 Suppose that you slowly lift a pail from the ground to a distance of 2 meters above the ground. The pail weighs 10N. How much work is done by the force that you exert on the pail?

a. -20Nm.

b. 20Nm.

c. 150Nm.

d. -150Nm.

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

a. $x = 0$.

b. $t = 0$.

c. $t = x = 0$.

d. $t = x$.

28 If a compass needle is brought near a magnet, it will point toward the magnet's

a. north-seeking pole.

b. bottom.

c. top.

d. center.

e. south-seeking pole.

29 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. twelve times the force in the first experiment.

b. the same as in the first experiment.

c. three times the force in the first experiment.

d. four times the force in the first experiment.

30 The formula for kinetic energy is

a. an independent law of nature.

b. a definition.

c. derived from Newton's Laws.

31 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. 100N.

b. 10N.

c. 20N.

d. 200N.

32 An anvil that weighs 300 pounds is dropped at the same time as a hammer that weighs 10 pounds. Assuming that both objects are dropped from the same height and air resistance can be neglected, which of the following statements would currently accepted ideas predict?

a. The hammer hits the ground long before the anvil.

b. The anvil hits the ground long before the hammer.

c. The hammer and anvil hit the ground almost together.

33 A jet plane (sometimes called the Vomit Comet) is supposed to provide the sensation of being weightless by accelerating downward at 9.8m/s^2. It accomplishes this purpose by following an arc that changes its rate of climb (the rate of increase in its distance above sea level). Which of the following situations will provide the desired downward acceleration?

a. rate of climb changes from $+9.8\text{m/s}^2$ to -9.8m/s^2 in one second.

b. rate of climb changes from -9.8m/s^2 to $+9.8\text{m/s}^2$ in one second.

c. rate of climb changes from -4.9m/s^2 to -9.8m/s^2 in one second.

d. Rate of climb changes from $+4.9\text{m/s}^2$ to -4.9m/s^2 in one second.

e. Rate of climb changes from -4.9m/s^2 to $+4.9\text{m/s}^2$ in one second.

34 Which of the following images is a virtual image?

a. The image on the film of a camera.

b. Objects seen in a mirror.

c. Objects seen through a window.

d. Pictures seen on a movie screen.

35 Newton's theory of universal gravitation implied small corrections to Kepler's laws because of

a. the curvature of space.

b. aether drag.

c. the forces exerted by the sun on each planet.

d. the force that each planet exerts on the other planets.

e. the effects of each planet's inertia.

36 In order to disprove Aristotle's ideas about falling objects, Galileo

a. found logical contradictions in Aristotle's ideas.

b. argued that his ideas were more elegant than Aristotle's.

c. sued Aristotle in Civil Court.

d. found a specific situation where Aristotle's ideas lead to a wrong prediction.

37 A negative charge of one micro-coulomb is one meter away from a much larger positive charge and has two joules of potential energy. If the charge moves to one half meter away from the positive charge, its potential energy could be

a. 1J.

b. 3J.

c. 2J.

38 If one of two charges is increased by a factor of 5 and the distance between the charges is not changed, then the electrical force between the charges is

a. multiplied by 5.

b. unchanged.

c. divided by 25.

d. divided by 5.

39 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

a. 2s.

b. less than 2s.

c. more than 2s.

d. an indeterminate amount of time.

40 The following notes are attached to some electrical devices. Which one can you safely ignore?

a. Danger! One million volts!

b. Danger! One million ohms!

c. Danger! One million amps!

41 When a runner begins a sprint by pushing off from a starting block, the force that causes the runner to accelerate is exerted by

a. the runners foot against the starting block.

b. the ground against the starting block.

c. the starting block against the runner's foot.

d. the runners leg muscles.

e. the starting block against the ground.

42 The requirement that relativistic mechanics should reduce to Newton's mechanics when v/c is small is an example of

a. The Correspondence Principle.

b. Mach's Principle.

c. The Principle of Conservation.

d. The Principle of Least Action.

e. The Anthropic Principle.

43 The potential energy of a charge of 3 micro-coulombs in a potential of 1 million volts is

a. 1J.

b. 6J.

c. 3J.

d. 2J.

44 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. twice that of the car.

b. nine times that of the car.

c. three times that of the car.

d. four times that of the car.

e. eight times that of the car.

45 Calculate (based on the assumptions made in class) the smallest potential difference that could possibly cause death to someone touching bare terminals with clean hands.

a. 5000V.

b. 50V.

c. 5V.

d. 120V.

e. 24V.

46 The Lorentz contraction was originally proposed as an explanation for

a. the null result of the Michelson Morely experiment.

b. the dragging of light by the aether.

c. the bending of light by the sun.

d. The perihelion precession of Mercury.

47 Suppose that a light intensity of 25W/m^2 causes a current of $4 \times 10^{-5}\text{A}$ to flow in a photocell. How much current will flow if the intensity is increased to 100W/m^2?

a. $8 \times 10^{-5}\text{A}$

b. $4 \times 10^{-5}\text{A}$

c. $1 \times 10^{-5}\text{A}$

d. $16 \times 10^{-5}\text{A}$

48 If light hits the surface of a pond, coming from air, at an angle of incidence of 45° it will travel into the pond (through the water) at an angle of

a. 32° from the vertical.

b. 54° from the vertical.

c. 45° from the vertical.

d. 90° from the vertical.

49 Consider two stones, one with twice the mass of the other. If you throw each stone equally hard,

a. the more massive stone will accelerate more.

b. the less massive stone will accelerate more.

c. both stones will be accelerated to the same speed.

50 A compass needle is used to test the magnetization of an object by putting the needle near every different part of the object and watching which way it points. Which of the following results is possible?

a. The needle always points toward the object.

b. The needle always points away from the object.

c. The needle points at some parts and away from others.

51 Which of the following answers is closest to the weight (on the Earth's surface) of a man whose mass is $100\,\mathrm{kg}$?

a. $100\,\mathrm{N}$.

b. $10\,\mathrm{N}$.

c. 10,000 N.

d. $1000\,\mathrm{N}$.

e. $100\,\mathrm{lb}$.

52 Your car runs out of gas just as you are about to go up a hill. You are moving at 40m/s when the engine quits and the top of the hill is 40 meters high. Make the optimistic assumption that friction can be neglected. Do you make it over the hill?

a. Just barely.

b. Yes, with speed to spare.

c. No. Not even close.

53 As you stand there under the TV cameras in your rubber-soled shoes, the evil game-show host tells you that all you must do to win a million dollars is to grasp two electrified handles. There are four handles labeled according to their potentials: 0V, 200V, 400V, 450V. Assuming that the labels are correct, which of the following pairs would give you the best chance of surviving to collect the money?

a. 200V and 400V.

b. 400V and 450V.

c. 0V and 200V.

d. 0V and 400V.

e. 200V and 450V.

54 A (hypothetical) atom has a ground state at -5eV, a first excited state at -2eV and a second excited state at -1eV. If a transition from the second excited state to the first excited state yields a photon of frequency f, then a transition from the second excited state to the ground state must yield a photon of frequency

a. $\frac{1}{3}f$

b. $4f$

c. $5f$

d. $2f$

e. $3f$

55 The photon theory predicts that the threshold frequency f_0 for the photoelectric effect

a. is usually zero.

b. is a universal constant.

c. depends on the light intensity.

d. depends on the work-function w.

56 Suppose that the nozzle of a fire hose emits a stream of water at a velocity of 30m/s and a rate of 10kg/s. Assuming that the water in the hose is moving at 10m/s, how much force does the nozzle exert on the fireman who is holding it?

a. $200\,\mathrm{N}$.

b. $100\,\mathrm{N}$.

c. $300\,\mathrm{N}$.

d. $0\,\mathrm{N}$.

57 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.

58 Suppose that a baseball is thrown with a horizontal velocity component of 30 m/s (about 66 miles per hour which is not too difficult) and a vertical velocity component of 10m/s. How far will it travel before coming back down to the level at which it was thrown?

a. 10m.

b. 80m.

c. 60m.

d. 20m.

e. 30m.

59 When the velocity of an object is tripled, its kinetic energy increases by a factor of

a. 8.

b. 36.

c. 4.

d. 2.

e. 9.

60 Which of the following surfaces would most likely be a diffuse reflector?

a. A water surface.

b. A polished metal surface.

c. Cotton cloth.

d. A window pane.

61 The Principle of Relativity states that

a. everything is relative to the reference frame used to describe it.

b. all reference frames are the same.

c. the laws of physics are the same in all moving reference frames.

d. the laws of physics are the same in all inertial reference frames.

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

a. Newton.

b. Galileo.

c. Kepler.

d. Halley.

63 An object is suspended a certain distance above the ground. If the distance is tripled, the gravitational potential energy of the object (relative to the ground) increases by a factor of

a. 2.

b. 3.

c. 27.

d. 4.

e. 9.

64 Several effects can limit the amount of unbalanced charge on an object. As the amount of unbalanced positive electric charge on a doorknob increases, which of the following limiting effects happens first?

a. Every atom in the doorknob has lost an electron.

b. Every atom on the surface of the doorknob has lost an electron.

c. Electrons pulled from surrounding atoms mob the doorknob.

65 Lateral inhibition refers to a type of image processing that occurs in

a. the optic nerve.

b. the cornea.

c. the brain.

d. the retina.

66 Compared to the force of gravitational attraction between two masses, the electrical force between two unbalanced charges is generally

a. much less than the force of gravity.

b. about the same as the force of gravity.

c. much more than the force of gravity.

67 The first demonstration of electromagnetic wave generation used

a. rapid mechanical switches.

b. charged mechanical rotors.

c. electric sparks in air.

d. vacuum tube oscillators.

68 Which way does the earth's magnetic field point at a position directly over the magnetic north pole (somewhere in the far north).

a. south.

b. up.

c. north.

d. down.

69 Each of the following statements is included in Newton's three laws. Most of the statements are really just definitions that say something about the language that we use but nothing about the real world. One of the statements says something about physical reality. Which one?

a. An object's resistance to acceleration depends only on the object and not at all on its surroundings.

b. Mass is resistance to acceleration. The acceleration of an object is inversely proportional to its mass.

c. Force is the cause of acceleration. The acceleration of an object is proportional to the force on it.

d. An inertial frame is one in which Newton's Law of inertia is obeyed.

70 You start driving your car at 5:00pm. At 6:00pm you have driven 60 miles and stop to rest. At 6:05pm you get back onto the highway and drive an additional 60 miles to your destination where you arrive at 7:00pm. What was the instantaneous rate of change of the distance from your starting point at 6:03pm?

a. 0 miles/hour.

b. 120 miles/hour.

c. 30 miles/hour.

d. 60 miles/hour.

71 A collection of atoms with many atoms in identical excited states might lase if it has

a. more atoms in the excited state than in any higher energy states.

b. equal numbers of atoms in the ground state and excited state.

c. more atoms in the excited state than in the ground state.

d. more atoms in the ground state than in the excited state.

72 Two identical clocks are set to the exact same time. One clock stays in the laboratory while the other clock is flown around the earth in a jet plane. When the clocks are brought back together, the flying clock reads

a. exactly the same time as the lab clock.

b. one tenth of a microsecond more time than the lab clock.

c. one tenth of a microsecond less time than the lab clock.

73 The number of waves that pass a given point in one second is called the

a. amplitude.

b. frequency.

c. wavelength.

d. wave velocity.

74 How much elastic potential energy is stored in a wall if leaning on it with an average force of 100N causes it to bow inward by one millimeter (0.001 meters).

a. 0.001J.

b. 100J.

c. 0.1J.

d. 1J.

75 A total eclipse of the sun happens when and where

a. the umbra of the earth's shadow touches the moon.

b. the umbra of the moon's shadow touches the earth.

c. the penumbra of the earth's shadow touches the moon.

d. the penumbra of the moon's shadow touches the earth.

76 When white light enters a prism, its different wavelengths are sent in different directions. When light goes out the other side of the prism, this separation of wavelengths

a. is completely canceled.

b. is increased.

c. is decreased but not canceled.

d. stays the same.

77 If the frequency of a wave increases by a factor of ten and its velocity stays the same, its wavelength will be multiplied by a factor of

a. 1.

b. 0.01.

c. 0.1.

d. 10.

78 An airplane is rolling down a runway with its engines at full throttle. The engines are generating a forward thrust of $30,000$N. There is also a drag force of $10,000$N due to air friction. The total force on this airplane is

a. $20,000$N forward.

b. $40,000$N forward.

c. $10,000$N upward.

d. $30,000$N forward.

e. $10,000$N backward.

79 The spectrum of Hydrogen gas describes

a. the wavelengths that it emits.

b. the amount of light that it emits.

c. the wavefunctions of its molecules.

d. the particles it is made out of.

80 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. 185,000 miles.

c. 187,000 miles.

d. 186,000 miles.

e. 2000 miles.

81 Optical illusions are primarily the result of the way images are

a. reconstructed by the brain.

b. formed on the retina.

c. transmitted to the brain.

d. processed in the eye.

82 Objects that are not interacting with anything appear to travel with constant velocity when they are described relative to

a. an inertial reference frame.

b. an equilibrium reference frame.

c. a non-fictitious reference frame.

d. a proper reference frame.

83 Which of the following light sources emits a continuous spectrum?

a. a neon light.

b. a glowing coal.

c. hot, thin interstellar gas.

d. a mercury-vapor lamp.

84 In the eye, some of the convergence that brings rays to a focus is supplied by the

a. retina.

b. pupil.

c. cornea.

d. iris.

85 A spacecraft fires a short burst from one of its maneuvering rockets. The total mass of the spacecraft (including fuel) is $10,100\,\mathrm{kg}$ before the burst. The burst ejects $100\,\mathrm{kg}$ of reaction mass at an exhaust velocity of $2000\,\mathrm{m/s}$. The resulting change in the velocity of the spacecraft is

a. $30\ \mathrm{m/s}$.

b. $3\ \mathrm{m/s}$.

c. $2\,\mathrm{m/s}$.

d. $20\ \mathrm{m/s}$.

e. $200\ \mathrm{m/s}$.

86 Light that consists of a single set of wavefronts is called

a. monochromatic.

b. constructive.

c. coherent.

d. polarized.

87 Suppose that your car turns a corner without slowing down. Which way does the acceleration vector of your car point?

a. forwards.

b. upwards.

c. backwards.

d. sideways.

88 The ampere is the MKS unit of electric

a. power.

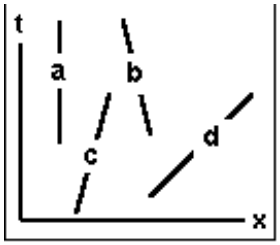
b. charge.

c. potential.

d. current.

e. resistance.

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



90 In relativistic mechanics, the one inertial reference frame that is uniquely defined for describing a moving object is

a. the inertial frame of the observer.

b. the instantaneous rest frame of the object.

c. the frame in which the microwave background is at rest.

d. the universal rest frame.

91 The ray approximation applies to light in the limit of

a. high intensity.

b. long wavelength.

c. short wavelength.

d. low intensity.

92 The eye stretches and relaxes its lens in order to

a. adapt its focus to objects at different distances.

b. adapt to changing light intensity.

c. center the image on the fovea.

d. keep the lens flexible.

e. express emotional interest.

93 Suppose that the focal point of a converging lens is 4cm from the lens. If an object is placed 3.9cm from the lens, then its image will be

a. reduced and virtual.

b. reduced and real.

c. enlarged and virtual.

d. enlarged and real.

94 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. 6:10 P.M.

b. 5:30 P.M.

c. 5:50 P.M.

d. 5:20 P.M.

95 Which of the following types of radiation has the shortest wavelength?

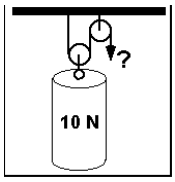
a. ultraviolet light.

b. X-rays.

c. violet light.

d. gamma rays.

96 A ten newton weight is hung from the ceiling with the pulley system shown here. The force that must be exerted on the end of the string to hold the weight in equilibrium is



a. $5\,\mathrm{N}$.

b. $10\,\mathrm{N}$.

c. $20\,\mathrm{N}$.

d. $3\frac{1}{3}\,\mathrm{N}$.

97 The average speed with which a change in electric potential moves through a wire is

a. close to the speed of sound.

b. close to the speed of light.

c. a few millimeters per second.

d. zero.

98 At 3:30 P.M. a swimming pool contains 2000 gallons of water. At 4:00 P.M. it contains 2500 gallons of water. The *rate* of change in the amount of water in the pool is

a. -1000 gal/hr.

b. +1000 gal/hr.

c. + 500 gal/hr.

d. - 500 gal/hr.

e. + 2000 gal/hr.

99 A lens that spreads parallel light rays apart is

a. wedge-shaped.

b. flat like a window pane.

c. thick in the middle and thin around the edges.

d. thin in the middle and thick around the edges.

100 The speed of a rocket will decrease whenever the rocket's acceleration vector

a. is zero.

b. is in the same direction as the rocket's velocity vector.

c. is in the opposite direction to the rocket's velocity vector.

d. is not zero.

101 In the MKS system of units, the kilogram is the unit of

a. mass.

b. momentum.

c. force.

d. acceleration.

e. velocity.

102 One joule per coulomb is defined to be

a. one watt.

b. one ampere.

c. one volt.

d. one ohm.

103 If our sun were to be compressed to the size of the earth — a factor of 100 smaller in radius — the weight of a 100kg object on its surface would

a. increase by a factor of 100.

b. decrease by a factor of 10,000.

c. decrease by a factor of 100.

d. increase by a factor of 10,000.

104 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. 4.

b. 3.

c. 9.

d. 2.

e. 16.

105 A hammer is thrown straight up with an initial velocity of 20m/s. The hammer is fairly heavy, so air resistance can be neglected. How long will it take to go up and fall back to the level at which it was thrown?

a. 0.5 s.

b. 20 s.

c. 10 s.

d. 4 s.

e. 2 s.

106 The light frequencies that a particular atom can absorb are always

a. greater than the frequencies that it can emit.

b. the same as the frequencies that it can emit.

c. less than the frequencies that it can emit.

d. independent of the frequencies that it can emit.

107 A rocket with a mass of 2000kg turns and fires its engine sideways with a thrust of 200, 000N. Because of this thrust, the rocket must be accelerating

a. sideways at 90m/s^2.

b. upward at 100m/s^2.

c. upward at 90m/s^2.

d. sideways at 100m/s^2.

108 When one coulomb of charge passes through a battery, the electrical potential energy of the charge increases by 1.5J. If 4 coulombs of charge pass through the same battery, its electrical potential energy will increase by

a. 3.0J.

b. 6.0J.

c. 1.5J.

d. 0.375J.

109 The *wave theory* predicts that electrons will be ejected from a metal surface by any light with

a. frequency below a threshold.

b. sufficient intensity.

c. frequency near a resonance.

d. frequency above a threshold.

110 An bullet that is fired from a gun keeps moving after it leaves the gun barrel because

a. it is round in the front and flat at the back.

b. not enough force acts on it to stop it.

c. the air that it pushes aside moves around behind it and pushes it forward.

d. the force of the gunpowder continues to act on it.

111 The idea that light would be dragged by the aether wind caused by the earth's motion around the sun was tested by

a. James Clerk Maxwell in 1865.

b. Heinrich Hertz in 1888.

c. Einstein in 1905.

d. Michelson and Morely in 1887.

112 A spaceship travels from the earth to a star that is 3 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.

113 The critical angle for a piece of glass is 42 degrees. In which of the following situations will light be 100% reflected?

Light coming

a. from the outside at a 40 degree angle of incidence.

b. from the outside at a 45 degree angle of incidence.

c. from the inside at a 40 degree angle of incidence.

d. from the inside at a 45 degree angle of incidence.

114 At 5:00 p.m., a truck is 120 miles from Richmond. At 7:00 p.m., the truck is 30 miles from Richmond. Calculate the truck's average velocity component away from Richmond.

a. +75 mi/hr.

b. +90 mi/hr.

c. -75 mi/hr.

d. -45 mi/hr.

e. +45 mi/hr.

115 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. $500,000$J.

d. $1,000,000$J.

e. $100,000,000$J.

116 When all of the internal forces on an object (the forces that one part of the object exerts on another part) are added up, the total is always equal to

a. zero.

b. the last force added.

c. the average force times the square root of the number of parts.

d. the difference between odd and even numbered forces.

117 Suppose that you weigh an object by hanging it from a rope that has a spring-scale that reads the amount of tension. Suppose, in addition, that you do this on a moving elevator. Under which of the following circumstances would you expect the scale to read less than the actual weight?

a. Elevator moving downward at constant velocity.

b. Elevator moving upward and slowing to a stop.

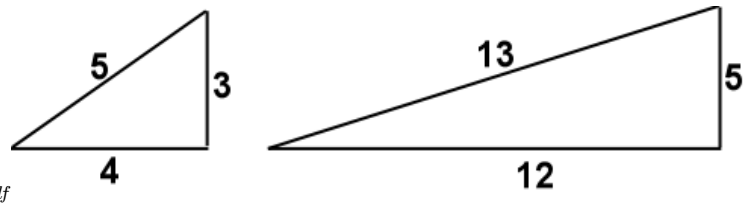
c. Elevator moving downward and slowing to a stop.

d. Elevator moving upward at constant velocity.

Useful Formulas

$p = mv$	$W = F_d d = F d_F$	$F = ma$
$\text{K.E.}_{\text{Newton}} = \frac{1}{2}mv^2$	$\text{P.E.} = mgh$	$W = mg$
$v = at$	$v^2 = 2ad$	$d = \frac{1}{2}at^2$
$v_{\text{average}} = \frac{d}{t}$	$\text{Eff} = \frac{\text{Work out}}{\text{Work in}}$	$P = \frac{\text{Work done}}{\text{Time taken}}$
$F = G\frac{mM}{D^2}$	$t_{\text{earth}} = \frac{T_{\text{ship}}}{\sqrt{1-v^2}}$	$E = \frac{mc^2}{\sqrt{1-(v/c)^2}}$
$F = k\frac{qQ}{D^2}$	$\text{K.E.}_{\text{Einstein}} = E - mc^2$	${T_{\text{ship}}}^2 = {t_{\text{earth}}}^2 - {x_{\text{earth}}}^2$
$E = \frac{\text{Force}}{\text{Electric charge}}$	$V = \frac{\text{P.E.}_{\text{electrical}}}{\text{Electric charge}}$	$I = \frac{\text{Charge flow}}{\text{Time taken}}$
$P = IV$	$R = \frac{V}{I}$	$v = f\lambda$
$E_{\text{photon}} = hf$	$hf = \text{K.E.}_{\text{electron}} + w$	$hf_{1\to 2} = E_1 - E_2$

Integer right triangles:
triangles



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Answer Key: Practice Final Exam 1

1 Choice c. (6:00 pm.)

2 Choice d. (0J.)

3 Choice a. (you hit the pigeon anyway.)

4 Choice b. (There is no such thing as a free lunch.)

5 Choice b. ($30\,\mathrm{m/s}$.)

6 Choice b. ($(1/12)$Mev.)

7 Choice e. (24V.)

8 Choice b. (opening and closing its pupil.)

9 Choice d. (is large enough to sometimes be of practical importance.)

10 Choice b. (velocity vector.)

11 Choice b. (Moving at constant speed down a long straight incline.)

12 Choice c. (more than 22 years old.)

13 Choice b. (it is still directly over the dolphin and hits the poor creature.)

14 Choice b. (through a vacuum.)

15 Choice a. (A)

16 Choice d. (converging lenses.)

17 Choice c. (converts energy.)

18 Choice e. (500mi/hr.)

19 Choice a. (smaller.)

20 Choice d. (only in inertial frames at rest relative to the aether.)

21 Choice b. (16N.)

22 Choice c. (9×10^7J.)

23 Choice b. (there is a negative charge at that point.)

24 Choice c. (60 degrees.)

25 Choice a. (1N upward.)

26 Choice b. (20Nm.)

27 Choice b. ($t = 0$.)

28 Choice e. (south-seeking pole.)

29 Choice a. (twelve times the force in the first experiment.)

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

31 Choice a. (100N.)

32 Choice c. (The hammer and anvil hit the ground almost together.)

33 Choice d. (Rate of climb changes from $+4.9$m/s^2 to -4.9m/s^2 in one second.)

34 Choice b. (Objects seen in a mirror.)

35 Choice d. (the force that each planet exerts on the other planets.)

36 Choice d. (found a specific situation where Aristotle's ideas lead to a wrong prediction.)

37 Choice a. (1J.)

38 Choice a. (multiplied by 5.)

39 Choice a. (2s.)

40 Choice b. (Danger! One million ohms!)

41 Choice c. (the starting block against the runner's foot.)

42 Choice a. (The Correspondence Principle.)

43 Choice c. (3J.)

44 Choice c. (three times that of the car.)

45 Choice b. (50V.)

46 Choice a. (the null result of the Michelson Morely experiment.)

47 Choice d. (16×10^{-5}A)

48 Choice a. (32° from the vertical.)

49 Choice b. (the less massive stone will accelerate more.)

50 Choice c. (The needle points at some parts and away from others.)

51 Choice d. ($1000\,\mathrm{N}$.)

52 Choice b. (Yes, with speed to spare.)

53 Choice b. (400V and 450V.)

54 Choice b. ($4f$)

55 Choice d. (depends on the work-function w.)

56 Choice a. ($200\,\mathrm{N}$.)

57 Choice a. (100m.)

58 Choice c. (60m.)

59 Choice e. (9.)

60 Choice c. (Cotton cloth.)

61 Choice d. (the laws of physics are the same in all inertial reference frames.)

62 Choice a. (Newton.)

63 Choice b. (3.)

64 Choice c. (Electrons pulled from surrounding atoms mob the doorknob.)

65 Choice d. (the retina.)

66 Choice c. (much more than the force of gravity.)

67 Choice c. (electric sparks in air.)

68 Choice d. (down.)

69 Choice a. (An object's resistance to acceleration depends only on the object and not at all on its surroundings.)

70 Choice a. (0 miles/hour.)

71 Choice c. (more atoms in the excited state than in the ground state.)

72 Choice c. (one tenth of a microsecond less time than the lab clock.)

73 Choice b. (frequency.)

74 Choice c. (0.1J.)

75 Choice b. (the umbra of the moon's shadow touches the earth.)

76 Choice b. (is increased.)

77 Choice c. (0.1.)

78 Choice a. ($20,000$N forward.)

79 Choice a. (the wavelengths that it emits.)

80 Choice d. (186,000 miles.)

81 Choice a. (reconstructed by the brain.)

82 Choice a. (an inertial reference frame.)

83 Choice b. (a glowing coal.)

84 Choice c. (cornea.)

85 Choice d. ($20\ \mathrm{m/s}$.)

86 Choice c. (coherent.)

87 Choice d. (sideways.)

88 Choice d. (current.)

89 Choice a. (A)

90 Choice b. (the instantaneous rest frame of the object.)

91 Choice c. (short wavelength.)

92 Choice a. (adapt its focus to objects at different distances.)

93 Choice c. (enlarged and virtual.)

94 Choice c. (5:50 P.M.)

95 Choice d. (gamma rays.)

96 Choice a. ($5\,\mathrm{N}$.)

97 Choice b. (close to the speed of light.)

98 Choice b. (+1000 gal/hr.)

99 Choice d. (thin in the middle and thick around the edges.)

100 Choice c. (is in the opposite direction to the rocket's velocity vector.)

101 Choice a. (mass.)

102 Choice c. (one volt.)

103 Choice d. (increase by a factor of 10,000.)

104 Choice a. (4.)

105 Choice d. ($4\,\mathrm{s}$.)

106 Choice b. (the same as the frequencies that it can emit.)

107 Choice d. (sideways at $100\mathrm{m/s}^2$.)

108 Choice b. (6.0J.)

109 Choice b. (sufficient intensity.)

110 Choice b. (not enough force acts on it to stop it.)

111 Choice d. (Michelson and Morely in 1887.)

112 Choice b. (4.)

113 Choice d. (from the inside at a 45 degree angle of incidence.)

114 Choice d. (-45 mi/hr.)

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

116 Choice a. (zero.)

117 Choice b. (Elevator moving upward and slowing to a stop.)

Where to find things in the notes

1 Module 103 Dispersion effects: Question 3.2
2 Module 019 Work: Question 4.4
3 Module 013 Projectile Motion: Question 2.1
4 Module 001 How to test a statement : Question 2.2
5 Module 012 Constant Acceleration: Question 1.4
6 Module r42 Relativistic Mechanics: Question 3.1
7 Module 086 Electrical Resistance: Question 2.2
8 Module 109 Anatomy: Question 4.1
9 Module r41 The Twin Paradox: Question 4.2
10 Module 009 The Acceleration Vector: Question 2.3
11 Module 016 The Law of Force and Mass: Question 4.3
12 Module r41 The Twin Paradox: Question 3.2
13 Module 013 Projectile Motion: Question 1.2
14 Module r34 Electromagnetic Waves: Question 3.1
15 Module r39 Map of a Moving Reference Frame: Question 3.1c Answer = A
16 Module 107 Optical Instruments: Question 3.4
17 Module 022 Total Energy: Question 3.2
18 Module 008 Speed: Question 3.5
19 Module 017 Some Forces: Question 2.2
20 Module r35 A Problem with Relativity: Question 2.2
21 Module 077 Coulomb's Force Law: Question 1.3
22 Module r42 Relativistic Mechanics: Question 4.2
23 Module 080 Definition of an Electric Field: Question 2.2
24 Module 102 Interactions at boundaries: Question 1.2
25 Module 080 Definition of an Electric Field: Question3.3
26 Module 019 Work: Question 2.4
27 Module r38 Maps of Spacetime: Question 1.2
28 Module 092 Magnetic Poles: Question 1.2
29 Module g31 Newton's Law of Universal Gravitation: Question 1.3
30 Module 021 Kinetic Energy: Question 1.1
31 Module 022 Total Energy: Question 5.3
32 Module 010 Universality of Free-fall: Question 2.2
33 Module 009 Components of Acceleration: Question 1.6
34 Module 105 Images: Question 3.1
35 Module g31 Newton's Law of Universal Gravitation: Question 4.2
36 Module 010 Universality of Free-fall: Question 3.2

37 Module 082 Electric Potential Energy: Question 2.1
38 Module 077 Coulomb's Force Law: Question 2.1
39 Module r40 Moving Clocks: Question 2.2
40 Module 086 Electrical Resistance: Question 1.1
41 Module 018 Action and Reaction: Question 2.3
42 Module r42 Relativistic Mechanics: Question 1.3
43 Module 083 Definition of Electric Potential: Question 2.2
44 Module 021 Kinetic Energy: Question 2.2
45 Module 086 Electrical Resistance: Question 4.2
46 Module r36 Michelson-Morely Experiment: Question 2.2
47 Module 117 The Photoelectric Effect: Question 4.1
48 Module 102 Interactions at boundaries: Question 3.2
49 Module 015 Mass, Measure of Inertia: Question 1.1
50 Module 092 Magnetic Poles: Question 3.1
51 Module 017 Some Forces: Question 1.3
52 Module 022 Total Energy: Question 1.2
53 Module 083 Definition of Electric Potential: Question 4.3
54 Module 118 Atomic Spectra: Question 2.4
55 Module 117 The Photoelectric Effect: Question 3.1
56 Module 018 Action and Reaction: Question 4.1
57 Module 021 Kinetic Energy: Question 5.4
58 Module 013 Projectile Motion: Question 4.2
59 Module 021 Kinetic Energy: Question 3.2
60 Module 102 Interactions at boundaries: Question 2.1
61 Module 014 The Law of Inertia: Question 3.2
62 Module g31 Newton's Law of Universal Gravitation: Question 3.1
63 Module 020 Potential Energy: Question 2.2
64 Module 077 Coulomb's Force Law: Question 4.3
65 Module 110 Image Processing: Question 1.1
66 Module 077 Coulomb's Force Law: Question 3.1
67 Module r34 Electromagnetic Waves: Question 2.1
68 Module 092 Magnetic Poles: Question 4.1
69 Module 015 Mass, Measure of Inertia: Question 2.2
70 Module 007 Instantaneous Rate of Change: Question 5.3
71 Module 119 Lasers: Question 2.2
72 Module r41 The Twin Paradox: Question 1.2
73 Module 099 Wave Properties: Question 3.1

74 Module 020 Potential Energy: Question 4.1
75 Module 104 The Ray Approximation: Question 3.3
76 Module 103 Dispersion effects: Question 1.3
77 Module 099 Wave Properties: Question 4.2
78 Module 016 The Law of Force and Mass: Question 3.1
79 Module 100 The Electromagnetic Spectrum: Question 4.1
80 Module r34 Electromagnetic Waves: Question 1.2
81 Module 110 Image Processing: Question 3.1
82 Module 014 The Law of Inertia: Question 2.3
83 Module 118 Atomic Spectra: Question 4.1
84 Module 109 Anatomy: Question 1.2
85 Module 018 Action and Reaction: Question 5.4
86 Module 119 Lasers: Question 3.2
87 Module 009 Acceleration and Speed: Circular Motion: Question 4A
88 Module 084 Electric Current: Question 1.4
89 Module r38 Maps of Spacetime: Question 3.3a
90 Module r42 Relativistic Mechanics: Question 2.2
91 Module 104 The Ray Approximation: Question 2.2
92 Module 109 Anatomy: Question 3.2
93 Module 107 Optical Instruments: Question 2.3
94 Module r39 Map of a Moving Reference Frame: Question 2.1
95 Module 100 The Electromagnetic Spectrum: Question 3.1
96 Module 018 Action and Reaction: Question 3.1
97 Module 084 Electric Current: Question 4.1
98 Module 007 Average Rate of Change Question 3N
99 Module 106 Lenses: Question 2.2
100 Module 009 Acceleration and Speed: Linear Motion: Question 3.4
101 Module 015 Mass, Measure of Inertia: Question 3.2
102 Module 083 Definition of Electric Potential: Question 1.2
103 Module g31 Newton's Law of Universal Gravitation: Question 2.1
104 Module 021 Kinetic Energy: Question 4.2
105 Module 012 Constant Acceleration: Question 4.5
106 Module 118 Atomic Spectra: Question 3.1
107 Module 016 The Law of Force and Mass: Question 2.2
108 Module 082 Electric Potential Energy: Question 4.1
109 Module 117 The Photoelectric Effect: Question 1.1
110 Module 005 The law of inertia.: Question 3.5

111 Module r36 Michelson-Morely Experiment: Question 1.2

112 Module r40 Moving Clocks: Question 4.3

113 Module 102 Interactions at boundaries: Question 4.1

114 Module 008 Components of Velocity: Question 1.5

115 Module 022 Total Energy: Question 2.2

116 Module 018 Action and Reaction: Question 1.1

117 Module 017 Some Forces: Question 4.2