

Last Name: _____ First Name: _____ ID _____

Instructions—

This is a closed book exam. You have seventy-five (75) minutes to complete it.

1. Use a #2 pencil on the bubble sheet. Darken each circle completely, but stay within the boundary. If you decide to change an answer, erase vigorously; the scanner sometimes registers incompletely erased marks as intended answers; this can adversely affect your grade. Light marks or marks extending outside the circle may be read improperly by the scanner. Be especially careful that your mark covers the **center** of its circle.
2. Print your **NETWORK ID** in the spaces designated for that on the answer sheet; then **mark the corresponding circle** below each character. If there is a letter “o” in your NetID, be sure to mark the “o” circle and not the circle for the digit zero. If and only if there is a hyphen “-” in your NetID, mark the hyphen circle at the bottom of the column. (Do not mark the hyphen circles for any other reason.) When you have finished marking the circles corresponding to your NetID, check particularly that you have not marked two circles in any one of the columns.
3. Print **YOUR LAST NAME** in the designated spaces at the *left* side of the answer sheet, then mark the corresponding circle below each letter. Do the same for your **FIRST NAME INITIAL**.
4. Do not write in or mark the circles in any of the other boxes (STUDENT NUMBER, DATE, SECTION, SCORES, SPECIAL CODE).
5. Sign your name (**DO NOT PRINT**) on the **STUDENT SIGNATURE** line.
6. You need not fill in the SECTION, COURSE or INSTRUCTOR lines.

*Before starting work, check to make sure that your test booklet is complete. You should have 12 **numbered pages** including a Formula Sheet.*

*Academic Integrity—***Giving assistance to or receiving assistance from another student or using unauthorized materials during a University Examination can be grounds for disciplinary action, up to and including expulsion.**

Exam Grading Policy—

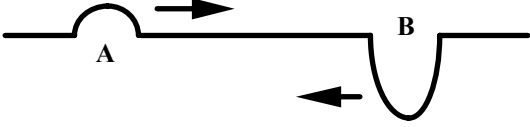
The exam consists of 46 questions. It is worth a total of 87 points, composed of three types of questions:

Multiple Choice: *multiple-choice questions, each worth 2 points. Record your answer on both your exam as well as the bubble sheet.*

True False: *true-false questions, each worth 1 point. Record your answer on both your exam as well as the bubble sheet.*

Short Answer: *short answer questions and numerical calculations, each worth 2 points. Write your answer on the exam. For numerical calculations, you must show your work to receive full credit.*

When you are finished, turn in both the exam and the bubble sheet.

- 1) Which of the following is transported by all traveling waves?
- particles.
 - energy.
 - light.
 - matter.
 - both energy and matter.
- 2) Two different continuous water waves on the surface of a pond would be expected to have roughly the same
- wave speeds.
 - wavelengths.
 - frequency.
 - energy.
 - amplitude.
- 3) Two brief waves or "pulses" are sent down a rope, in opposite directions, as shown in the diagram to the left. Pulse A is 1 cm in height, and pulse B is 2 cm in depth. When they meet, they will create
- a disturbance 3 cm high.
 - a disturbance 3 cm deep.
 - a disturbance 1 cm high.
 - a disturbance 1 cm deep.
 - no disturbance, because they cancel.
- 
- The diagram shows a horizontal rope with two pulses. Pulse A is a crest (upward bump) moving to the right, indicated by a right-pointing arrow above it. Pulse B is a trough (downward bump) moving to the left, indicated by a left-pointing arrow above it. The pulses are separated by a distance on the rope.
- 4) The force between two bar magnets cannot be due to gravity, because
- the force between magnets is far too large to be caused by gravity.
 - the force between magnets can be repulsive, while gravity must be attractive.
 - both of the above.
 - the force of gravity is always downward, unlike the magnetic force.
 - all of the above.
- 5) Is the force holding the electrons into their atomic orbits in an individual atom basically the same as the force that hold the sun's planets in their orbits? Why or why not?
- Yes; it is the force of gravity in both cases.
 - Yes; it is the centrifugal force in both cases.
 - No; gravity holds planets in their orbits, while the electromagnetic force holds electrons in their orbits.
 - No; gravity holds the sun's planets in their orbits, while nuclear forces hold the electrons in their orbits.
 - No; the sun's energy source is nuclear fusion, and fusion does not occur within individual atoms.

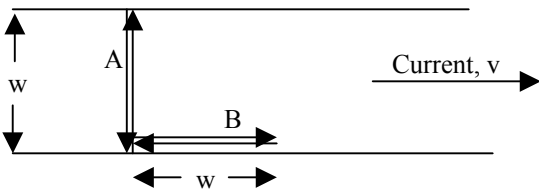
- 6) Which of these is the best explanation of the "electric hair" that can occur when some people brush their hair?
- Excess electrons flow onto both the brush and the hair, causing the hairs to repel each other and causing the brush to repel the hairs.
 - The atoms of the brush and hair are heated, causing their electrons to move faster, which spreads out the atoms and thus causes the hairs to stand up.
 - The atoms of the brush and hair are set into rapid vibration, causing them to emit electromagnetic waves, which causes the hairs to stand up.
 - Electrons are brushed either from the hair onto the brush, or vice-versa, causing the brush and hair to be charged, so that the hairs then repel each other while the brush attracts the hairs.
 - Electrons are brushed either from the hair onto the brush, or vice-versa, causing the brush and hair to be charged, so that the hairs then attract each other while the brush repels the hairs.
- 7) An electromagnetic field
- can exist in vacuum.
 - is a region of space where a charge would feel a force.
 - Both of the above.
 - None of the above.
- 8) A proton moves through a room that is isolated from all external influences and that has no matter inside it other than the single proton. Which of the following would we expect to find at some other point X [away from the proton] inside the room?
- an electric field.
 - a magnetic field.
 - both of the above.
 - an electric force.
 - no fields or forces of any kind.
- 9) Is it possible to send waves to the moon from Earth?
- No, because there is no air between the earth and moon.
 - No, because there is no medium of any kind between the earth and moon.
 - Yes, we could conceivably send a sufficiently loud sound wave.
 - Yes, we could send an electromagnetic wave.
 - Yes, we could send a water wave---in fact, we plan to colonize the moon, and solve the Los Angeles smog problem, by sending the entire population of California there on surfboards.
- 10) You flip a coin 100 times and get "heads" 80 times and "tails" 20 times. From this result, you can immediately tell that the experiment was biased.
- TRUE.
 - FALSE.

- 11) Suppose that the light from the sun suddenly shut off all over the sun, precisely at noon, as measured by clocks placed near the sun. Viewed from Earth, how would this appear? HINT: It is about 8 light-minutes to the sun.
- At noon, all sunlight would suddenly cease.
 - At about 8 minutes past noon, all sunlight would suddenly cease.
 - Nothing unusual would happen, as viewed from Earth.
 - At about 8 minutes past noon a small black spot would appear in the center of the sun, and this black spot would rapidly spread out over the entire sun.
 - After about 8 minutes, the sun would turn into Daffy Duck.
- 12) Two charged particles are placed a short distance apart, in vacuum. The electric force by one on the other
- cannot be felt due to the vacuum.
 - is transmitted instantaneously.
 - is transmitted at the speed of light.
 - is due to gravity.
 - is due to friction.
- 13) For light waves, different frequencies mean different
- brightness.
 - colors.
 - amplitudes.
 - speeds.
 - none of the above.
- 14) Velma can throw at 10 m/sec. She is on a train headed north at 30 m/s. She throws a ball toward the rear of the train. Mort, standing by the tracks, sees the ball move at a velocity of
- 20 m/s south.
 - 20 m/s north.
 - 30 m/s north.
 - 40 m/s south.
 - 40 m/s north.
- 15) According to the principle of relativity, an observer who has no communication with the world outside of her laboratory will be unable to detect
- her laboratory's acceleration.
 - her laboratory's velocity.
 - both of the above.
 - gravity.
 - all of the above.
- 16) A wave has amplitude of 1m and wavelength of 0.1m. If we double the amplitude of the wave to 2m, the wavelength changes to 0.05m.
- TRUE
 - FALSE.

- 17) Einstein proposed two basic postulates or laws as the foundation of his special theory of relativity. Which one of the following is one of these postulates?
- $E=mc^2$.
 - the principle of time dilation.
 - the principle of non-simultaneous events.
 - the principle of inertia.
 - the principle of relativity, the laws of physics are the same for all inertial observers.
- 18) If you drop a coin inside a car that is slowing down, the coin will land
- to the rear of the drop point.
 - in front of the drop point.
 - right under the drop point.
 - to the side of the drop point.
 - in St. Louis.
- 19) Velma is in a rocket ship moving north, past Mort, at a speed of $0.25c$. She "fires" a laser beam in the forward direction. Mort sees the tip of this beam move at a speed of
- $0.75c$.
 - c .
 - $1.25c$.
 - $0.25c$.
 - infinite speed.
- 20) According to the theory of relativity, is everything relative?
- Yes.
 - No, the speed of light is not relative.
 - No, time and space are not relative.
 - No, velocity is not relative.
 - No, mass is not relative.
- 21) Before Einstein, scientists thought that the substance that was "waving" when a light wave was transmitted was
- air.
 - phlogisten.
 - plasma.
 - ether.
 - they didn't think any material substance was waving.
- 22) In the "special theory of relativity," what does the word "special" refer to?
- This theory is restricted to the study of light beams.
 - This theory is restricted to the observations of accelerated observers.
 - This theory is restricted to the observations of non-accelerated observers.
 - This theory is restricted to the observations of stationary observers.
 - This theory is restricted to the study of gravitational forces.

- 23) Velma passes Mort at a high speed. According to Mort, his clock has progressed by one hour while Velma's clock progressed by only 40 minutes. What does Velma observe?
- a) Mort's clock progressed by one hour while Velma's progressed by 40 minutes.
 - b) Mort's clock progressed by one hour while Velma's clock progressed by 80 minutes.
 - c) Mort's clock progressed by 40 minutes while Velma's clock progressed by one hour.
 - d) both clocks progressed by one hour.
 - e) The answer cannot be determined, because we don't know Velma's speed.
- 24) One experimental observation that demonstrates Einstein's ideas on the relativity of time, is
- a) muons "live" longer when moving rapidly than they do when they are at rest.
 - b) a laser beam emitted from an orbiting satellite is observed from Earth.
 - c) electromagnetic waves from the early stages of the development of the universe have slower rates of vibration, due to the relativity of time.
 - d) the careful observation of the frequencies of rapidly-rotating neutron stars shows that they spin more slowly than they would if they weren't moving rapidly away from us.
 - e) the recent discovery of very fast-moving particles known as tachyons.
- 25) Suppose you are on a rocket ship passing lengthwise over a football stadium at 90% of the speed of light. The playing field is 100 m long as measured by the players, and your rocket ship is 100 m long as measured by you. An observer in the stadium will observe your ship to be
- a) shorter than 100 m.
 - b) longer than 100 m.
 - c) 100 m long.
- 26) Continuing the preceding question, you will observe the football field to be
- a) shorter than 100 m.
 - b) longer than 100 m.
 - c) 100 m long.
- 27) Velma passes Mort at a high speed. Each holds a meter stick, oriented perpendicular to the direction of relative motion. Mort observes that
- a) his meter stick and Velma's meter stick are both shorter than 1 m.
 - b) his meter stick is longer than 1 m, and Velma's meter stick is 1 m long.
 - c) his meter stick is 1 m long, and Velma's meter stick is longer than 1 m.
 - d) his meter stick and Velma's meter stick are both 1 m long.
 - e) his meter stick is 1 m long, and Velma's meter stick is less than 1 m long.

- 28) When we set up two stereo speakers in class, depending upon where you are at, the volume you hear changes. This is an example of diffraction.
- TRUE.
 - FALSE.
- 29) If you were to travel at speeds close to the speed of light, you would notice that your
- mass has increased.
 - pulse has slowed.
 - body has shortened along the direction of motion.
 - all of the above.
 - none of the above.
- 30) Mort is on Earth, and Velma passes him at a high speed. Mort and Velma each carry a standard kilogram. Concerning the kilograms, Velma observes that
- Velma's has a mass of 1 kilogram, but Mort's is more massive than 1 kilogram.
 - Velma's has a mass of 1 kilogram, but Mort's is less massive than 1 kilogram.
 - both have a mass of 1 kilogram.
 - Velma's is more massive than 1 kilogram and Mort's has a mass of 1 kilogram.
 - Velma's is less massive than 1 kilogram and Mort's has a mass of 1 kilogram.
- 31) Can a rock be accelerated up to the speed of light?
- No, because the light beams will push back on it, slowing it down.
 - No, because any material object's length decreases to zero as the object approaches the speed of light.
 - No, because any material object's mass becomes infinite as the object approaches the speed of light.
 - Yes, as we can see from the example of light itself.
 - Yes, by projecting the object at a sufficiently high speed from a reference frame that is already moving at a high speed.
- 32) According to Einstein's theory of relativity, matter is a form of
- energy.
 - radiation.
 - anti-matter.
 - popcorn.
 - thought.
- 33) Which of the following properties do waves exhibit that particles do not.
- Collisions.
 - Interference.
 - Conservation of energy.
 - Conservation of momentum.

- 34) A bar magnet has a north and south pole. What happens when you cut the magnet in half?
- You have two magnets, one has a north pole and one has a south pole.
 - You have two magnets, each has both a north and south pole.
 - The magnetism is lost.
 - You can't cut magnets in half.
- 35) Which of the following is true regarding experimental results?
- An experimental measurement has a statistical error associated with the sample size.
 - An experimental measurement has a systematic error that may come about due to bias or imperfections in the experiment.
 - Both a) and b) are true.
 - If an experimental measurement has a statistical error, then it has no systematic error, and vice versa.
- 36) The Michelson-Morley experiment was set-up to measure what quantity?
- The motion of Earth through the ether.
 - The motion of the air around Earth.
 - The time it takes for light to travel in air.
 - The motion of the ether near Earth.
- 37) Two swimmers can swim at the same speed with respect to the water. A stream moves with water current velocity v . Swimmer A swims across a stream and back, traveling a distance $2w$. Swimmer B swims downstream and then upstream, traveling a distance $2w$. They leave at the same time. Who wins the race?
- Swimmer A.
 - Swimmer B.
 - It's a tie.
- 
- The diagram shows a stream of width w between two horizontal lines. A horizontal arrow labeled "Current, v " points to the right. Swimmer A is represented by a vertical double-headed arrow labeled "A" spanning the width w . Swimmer B is represented by a horizontal double-headed arrow labeled "B" spanning a distance w in both directions from a central point.
- 38) The first measurements of the speed of light were made by observing eclipses of the moons of Jupiter.
- TRUE
 - FALSE
- 39) Maxwell unified electricity and magnetism just as Newton unified our understanding of mechanics.
- TRUE.
 - FALSE.

Short Answer. Write your answers on the exam. For numerical calculations, you must show your work. For numerical answers, you must include dimensions.

40) You are outside in the summer when a thunderstorm rolls in. You see a flash of lightning and 15 seconds later you hear the clap of thunder. How far away from you was the lightning strike?

41) Velma passes Mort at speed $v=0.8c$. According to Mort, 10 seconds pass on his clock. According to Velma, how much time has passed on Mort's clock?

42) Velma passes Mort at speed $v=0.8c$. According to Velma, Mort's clock runs slow. According to Mort, Velma's clock runs slow. How can these two observations be consistent with one another?

43) Name two issues in science or technology that are relevant in this year's presidential election.

44) Velma passes Mort at speed $v=0.8c$. Mort is holding a meter stick parallel to the direction of Velma's motion.

a) How long is the meter stick according to Mort?

b) How long is the meter stick according to Velma?

45) An object with a rest mass of 1kg is observed to have 9×10^{16} J of kinetic energy. What is mass of the object?

46) An electromagnetic wave is observed to have a wavelength $\lambda=300\text{m}$. What is the frequency of this wave?

<p>Did you bubble in your name, exam version and your network ID? Check to make sure you have bubbled in all your answers.</p>

Formula Sheet**General relations:**

Distance = speed * time

$$\text{velocity} = \frac{\text{distance traveled}}{\text{elapsed time}} \quad \text{acceleration} = \frac{\text{change in velocity}}{\text{elapsed time}}$$

$$KE = \frac{1}{2}mv^2 \quad \vec{F} = m\vec{a} \quad \vec{p} = m\vec{v}$$

For constant acceleration:

$$\vec{v} = \vec{a}t \quad d = \frac{1}{2}\vec{a}t^2$$

Gravity near the Earth's surface:

$$g = 10 \text{ m/s}^2 = 32 \text{ ft/s}^2 \quad \text{Weight} = mg \quad \text{PE} = mgh$$

Waves:

$$v = f\lambda \quad c = 3 \times 10^8 \text{ m/s} \quad v_{\text{sound}} = 330 \text{ m/s}$$

Special Relativity:

$$\gamma = \frac{1}{\sqrt{1 - \left(\frac{v^2}{c^2}\right)}}, \quad c = 3 \times 10^8 \text{ m/s.}$$

$$T(\text{moving}) = \gamma T_{\text{proper}}$$

$$L_{\text{parallel}}(\text{moving}) = L_{\text{parallel}}(\text{rest}) / \gamma$$

$$L_{\text{perpendicular}}(\text{moving}) = L_{\text{perpendicular}}(\text{rest})$$

$$m(\text{moving}) = \gamma m_0, \quad m_0 = m(\text{rest})$$

$$E = mc^2 = \gamma m_0 c^2$$