**Dan Watson** **Astronomy 102, Fall 2009**

**Practice Midterm Exam 1** **Due date: 09/26/2009 at 12:15am EDT**

IMPORTANT: Don't open two WeBWorK windows or tabs at the same time while you're taking the test. It's safe to enter and leave a WeBWorK session (pushing the Grade button before leaving, of course), but it causes difficulties for the database for one certain kind of exam problem, if one is logged in twice.

The exam mode of WeBWorK has several differences from the homework mode. Instead of submitting each answer as you enter it, you submit all of the answers entered hitherto, every time you push the Grade button. As you will have to do on the real exam, you may push the Grade button no more than seven times during the test. You may still look ahead, and work the problems in a different order than they are presented. When you first open the test, a timer appears that will count down your allotted 75 minutes. WeBWorK will start urging you to finish when there are 90 seconds to go. It will stop accepting answers either after you have pushed the Grade button seven times, or after time has run out.

After starting a version of the test, you can return to the WeBWorK "ast102s09" page and download a pdf copy for printing.

In the exam mode there is no Feedback button. However, you may still send email to the professor and TAs by using (for instance) the links on the course website's Contacts page, if problems arise on the practice test. Someone will reply as swiftly as they may. Note that, because this is a test, we can only answer questions to clarify, not as we do at other times, to help lead you to the answer.

As usual, enter your numerical answers with at least three-significant-figure precision. To use scientific notation, write your answer in the form xxE+yy. It is important that you use a capital E; answers with a lower case e will be evaluated differently.

Every time you push the Grade button, you will get an update of which problems you have answered. WeBWorK will remember the best answer you submitted for each problem in your final total. If you submit an incorrect answer for a problem to which you haved previously submitted a correct answer, that problems points won't appear in that particular submission, but will appear in your final total.

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**Problem 1.**

Two identically-made, 100 meter long spaceships can be seen; each is moving at 0.99 times the speed of light, with one of them approaching you, and one receding from you. The colors of the spaceships appear to you as follows

- A. the approaching ship looks redder, the receding one bluer, than their natural colors.
- B. the approaching ship looks bluer, the receding one looks redder (longer wavelength light), than their natural colors.
- C. their colors are unchanged.
- D. both look redder than their natural colors.
- E. both look bluer (shorter wavelength light) than their natural colors.

*Answer submitted:*

- `B (correct)`

*Correct Answers:*

- `B`

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**Problem 2.**

The most important reason for considering Einstein's special theory of relativity to be valid is

- A. the elegance and logical consistency of Einstein's development of his theories.
- B. the success of classical physics in predicting planetary motions correctly.
- C. the successful prediction from the classical Maxwell equations of hitherto undiscovered phenomena, such as radio waves.
- D. the precise agreement of the predictions of Einstein's theory and the experimental results.
- E. All of the above are equally important reasons.

*Answer submitted:*

- `D (correct)`

*Correct Answers:*

- `D`

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**Problem 3.**

Select all the correct statements from the following list.

Consider two black holes, one of mass $10^{33}$ gm, and the other of mass $10^{35}$ gm. The following quantities are greater for the more massive black hole.

- A. force due to gravity on an object 100 light years away.
- B. tidal force in an orbit with circumference twice as large as the horizon.
- C. horizon circumference.
- D. force due to gravity on an object just barely above the horizon.
- E. All of the above.
- F. None of the above.

*Answer submitted:*

- `( A, C )  (correct)`

*Correct Answers:*

- `AC`

**Problem 4.**

Select all the correct statements from the following list.

At a distance corresponding to a circle with circumference 1.0001 times the horizon circumference from a $10^{14} M_{\odot}$ black hole, one would experience the following effects.

- A. A vertical descent was necessary in order to reach this point; there are no stable orbits this close to the black hole.
- B. One can use a telescope to see the back of one's own head.
- C. A laser used to signal a distant observer looks normal to those near the horizon, but the laser light appears to that distant observer to have much longer wavelength than normal.
- D. The tidal forces would be extremely large and probably rip one to bits.
- E. Distant clocks (far away from the black hole) appear to be running very slowly.
- F. The sky is compressed into a small circle directly overhead.

*Answer submitted:*

- ( A, C, F ) (correct)

*Correct Answers:*

- ACF

**Problem 5.**

Apu has opened a Kwik-E-Mart on a train that travels around Springfield at a speed of 0.85c. In celebration of this momentous event, Homer has decided to sit on his couch and watch it go by his house. At one point, Apu–who of course is in the store, behind the counter–notes that the hot dogs have been sitting out for one hour. How many hours would Homer say they've been sitting out? _____

*Answer submitted:*

- 1.898 (correct)

*Correct Answers:*

- 1.898315991505

**Problem 6.**

The new Kwik-E-Mart is in the back of the 53000 cm train. One day, just when Homer is watching the store go past, the Squishee machine breaks. Apu sees a firecracker explode at the front of the train 1.1e-06 sec later. Homer sees the firecracker go off 7.1e-06 after the Squishee machine breaks. What is the distance in centimeters between these two events – Squishee machine breakdown and firecracker explosion – according to Homer?_____

*Answer submitted:*

- 2.169E5 (correct)

*Correct Answers:*

- 216858.836098166

**Problem 7.**

To be valid, a scientific experiment must

- A. give the same results as others get, who repeat the experiment correctly.
- B. have sufficient accuracy to distinguish between the predictions of different, prevailing theories.
- C. have a reliably-estimated accuracy.
- D. All of the above.
- E. None of the above.

*Answer submitted:*

- D (correct)

*Correct Answers:*

- D

**Problem 8.**

Two identically-made, 100 meter long spaceships can be seen; each is moving at 0.99 times the speed of light, with one of them approaching you, and one receding from you. Their lengths appear to you as follows:

- A. the approaching ship looks much shorter, the receding one much longer, than 100 meters.
- B. the approaching ship looks much longer, the receding one much shorter, than 100 meters.
- C. both look much shorter than 100 meters.
- D. both look much longer than 100 meters.

*Answer submitted:*

- C (correct)

*Correct Answers:*

- C

**Problem 9.**

Select all the correct statements from the following list.

The following attributes are required of a scientific theory before it is considered valid:

- A. Predictions that can be tested experimentally.
- B. Aesthetic (i.e. 'artistic') appeal
- C. Disagreement with other, competing theories.
- D. Public support.
- E. Mathematical and/or logical self-consistency.
- F. Precise agreement with experimental results.
- G. Tangible benefits to society.
- H. Agreement with expert opinion.

*Answer submitted:*

- ( A, E, F ) (correct)

*Correct Answers:*

- AEF

**Problem 10.**

Tidal forces, dangerously strong, prevent you from getting as close as you want to a certain black-hole horizon. To get closer without getting killed, you need to

- A. descend directly to the horizon, as circular orbits are not allowed this close.
- B. choose a much smaller black hole, to decrease the total gravity.
- C. orbit the hole faster than the speed of light.
- D. choose a much larger black hole, to move to the horizon further away from the singularity.

*Answer submitted:*

- `D (correct)`

*Correct Answers:*

- `D`

**Problem 11.**

Standing at rest, and holding a light in each hand with arms outstretched, I flash the lights simultaneously. You and a friend of yours are flying toward me at 0.9c in opposite directions, parallel to my arms. To the two of you, the lights appear to flash

- A. simultaneously, but the lights look redder than normal.
- B. at different times, but the two of you agree on the time between the flashes.
- C. at different times, and the intervals that the two of you measure are different.
- D. simultaneously.

*Answer submitted:*

- `B (correct)`

*Correct Answers:*

- `B`

**Problem 12.**

Select all the correct statements from the following list.

What quantities, considered relative in classical physics, were treated as absolute by Einstein?

- A. Luminosity.
- B. The absolute interval.
- C. The speed of light.
- D. Distance.
- E. Time.
- F. The Michelson-Morley experiment.
- G. Simultaneity.
- H. Gravity.
- I. Velocity.

*Answer submitted:*

- `( B, C ) (correct)`

*Correct Answers:*

- `BC`

**Problem 13.**

An important experimental result that confirmed the predictions of the general theory of relativity was

- A. the direct demonstration of time dilation in high-energy particle accelerators.
- B. the deflection of starlight by the Sun.
- C. the Maxwell equations.
- D. the Michelson-Morley experiment.
- E. None, all these were confirmations of the special theory of relativity, not the general theory.

*Answer submitted:*

- `B (correct)`

*Correct Answers:*

- `B`

**Problem 14.**

You and I are both in freely-falling reference frames. Our motion can be described as follows:

- A. we must move at a constant speed with respect to each other.
- B. we must accelerate with respect to each other.
- C. we must be at rest with respect to each other.
- D. any state of relative motion is allowed, as long as the speed of light is not exceeded.

*Answer submitted:*

- `A (correct)`

*Correct Answers:*

- `A`

**Problem 15.**

The region immediately surrounding the black hole in a certain quasar has a luminosity of 11500000000000 $L_{\odot}$. This is larger than the luminosity of our Milky Way galaxy by a factor of _____ .

*Answer submitted:*

- `575 (correct)`

*Correct Answers:*

- `575`

**Problem 16.**

You are at rest in a part of space far from any strong gravitational fields, and a friend of your flies past at nearly the speed of light, with a constant acceleration equal to one earth gravity. You get a good look at each other's clock as she passes by.

- A. You see your friend's clock ticking faster than yours, and she sees your clock ticking more slowly than hers.
- B. You see your friend's clock ticking more slowly than yours, and she sees your clock ticking faster than hers.
- C. You each see the other's clock ticking faster than your own.
- D. You each see the other's clock ticking more slowly than your own.

*Answer submitted:*

- `B (correct)`

*Correct Answers:*

- `B`

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**Problem 17.**

I can place either of two objects in a spot $7.8 \times 10^8$ km (the Jupiter-Sun distance) away from you: a 1 $M_\odot$ star, and a 1 $M_\odot$ black hole, which has horizon circumference 18.6 km. How could you tell which one is there, without looking?

- A. By comparing the tidal forces: they will be much larger when the black hole is there.
- B. By comparing the pace at which your wristwatch ticks: it will run slower in the presence of black holes.
- C. By comparing the pull you feel toward the object: the black hole pulls harder.
- D. You can't.

*Answer submitted:*

- `D (correct)`

*Correct Answers:*

- `D`

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**Problem 18.**

Select all the correct statements from the following list.

These are observable properties that are useful in detecting the presence of a black hole from a great distance:

- A. A black patch in the sky.
- B. X-ray emission.
- C. Large tidal gravity.
- D. Radio-wave emission.
- E. A hot disk of material with two high-speed (close to the speed of light) jets of matter protruding from its poles.
- F. Stars and gas clouds moving in orbits at speeds close to that of light.
- G. A clock running very slowly.

*Answer submitted:*

- `( B, E, F ) (correct)`

*Correct Answers:*

- `BEF`

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**Problem 19.**

You are running at 99.9

- A. yourself.
- B. yourself, but contracted along the direction of your motion.
- C. yourself, with the colors in the mirror bluer than normal.
- D. nothing.

*Answer submitted:*

- `A (correct)`

*Correct Answers:*

- `A`

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**Problem 20.**

You are near the horizon of a massive black hole. The stars in the sky appear to be

- A. bluer in color than normal.
- B. perfectly normal.
- C. redder in color than normal.
- D. larger than normal.
- E. none of the above.

*Answer submitted:*

- `A (correct)`

*Correct Answers:*

- `A`

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**Problem 21.**

You observe a friend of yours rolling bowling balls on a moving flatbed truck. She rolls the balls at 10 km/sec west with respect to the truck, and the truck itself moves west at 10 km/sec with respect to you. According to the laws of classical (Newtonian) physics, the velocity of the bowling balls with respect to you is

- A. 10 km/sec west.
- B. 10 km/sec east.
- C. 20 km/sec west.
- D. $2.9979 \times 10^5$ km/sec west.

*Answer submitted:*

- `C (correct)`

*Correct Answers:*

- `C`

**Problem 22.**

You observe a friend of yours rolling bowling balls on a moving flatbed truck. She rolls the balls at 10 km/sec west with respect to the truck, and the truck itself moves west at 10 km/sec with respect to you. According to the special theory of relativity, the velocity of the bowling balls with respect to you is

- A. 10 km/sec west.
- B. 20 km/sec west.
- C. 29.979 km/sec west.
- D. $2.9979 \times 10^5$ km/sec west.

*Answer submitted:*

- `B (correct)`

*Correct Answers:*

- `B`

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**Problem 23.**

You observe a friend of yours rolling bowling balls on a moving flatbed truck. She rolls the balls at 90

- A. 10 km/sec west.
- B. 80
- C. 99
- D. 180

*Answer submitted:*

- `D (correct)`

*Correct Answers:*

- `D`

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**Problem 24.**

You observe a friend of yours rolling bowling balls on a moving flatbed truck. She rolls the balls at 90

- A. 10 km/sec west.
- B. 80
- C. 99
- D. 180

*Answer submitted:*

- `C (correct)`

*Correct Answers:*

- `C`

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**Problem 25.**

A certain bright star lies 1.2e+19 cm away from Earth. In light years, that distance is: _____

*Answer submitted:*

- `12.68 (correct)`

*Correct Answers:*

- `12.6849894291755`

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**Problem 26.**

You are in orbit around a black hole; your orbit's circumference is 2.6 times larger than the circumference of the horizon. To change to an orbit closer to the horizon, you must:

- A. fire your thrusters in the direction you're traveling, which would slow you down under normal circumstances.
- B. fire your thrusters opposite to the direction you're traveling, which would speed you up under normal circumstances.
- C. descend directly to the horizon, since orbital speeds would exceed the speed of light if you were any closer.
- D. do nothing, since you are in the inexorable grip of a black hole and cannot escape.

*Answer submitted:*

- `B (correct)`

*Correct Answers:*

- `B`

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**Problem 27.**

According to Einstein, the effects we know as tides are caused by

- A. the Doppler effect.
- B. the principle of equivalence.
- C. the relativity of simultaneity.
- D. the curvature of spacetime by gravity.

*Answer submitted:*

- `D (correct)`

*Correct Answers:*

- `D`

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**Problem 28.**

We are running together in the same direction, at a speed 0.999 times the speed of light. I hold up a mirror facing you, and in my mirror you see

- A. yourself, with the colors in the mirror bluer than normal.
- B. yourself, but moving slowly.
- C. yourself, but contracted along the direction of your motion.
- D. yourself.
- E. All of the above.
- F. None of the above.

*Answer submitted:*

- `D (correct)`

*Correct Answers:*

- `D`

**Problem 29.**
You and I are both in inertial reference frames. Therefore

- A. the special theory of relativity does NOT apply to us.
- B. the special theory of relativity applies to us both.
- C. any state of relative motion is allowed, as long as the speed of light is not exceeded.
- D. we must fall freely under the influence of gravity.
- E. we must accelerate with respect to each other.

*Answer submitted:*

- `B (correct)`

*Correct Answers:*

- `B`

**Problem 30.**
A meter stick flies past you at 0.81 times the speed of light, laying along its direction of motion. In an instant, you measure its length as it flies past. Your result, expressed in meters, is _____

*Answer submitted:*

- `0.586 (correct)`

*Correct Answers:*

- `0.58642987645583`

**Problem 31.**
You wake up one morning to find that the Moon has somehow turned into a black hole of the Moon's former mass. You own a beach house, which would be wiped out if the tides increase dramatically. Should you sell the house quickly to someone who knows little of the dangers of black holes?

- A. No; the tides will increase, but not by very much, since the Earth is so far from the horizon of the new black hole.
- B. Yes, but you will have to spend the money fast because we will all soon be sucked into the new black hole.
- C. Yes; the ocean tides will be strongly affected by the black hole's spacetime curvature.
- D. No; the tides will be exactly the same as before, since gravity is the same outside the Moon's former volume as it was before.

*Answer submitted:*

- `D (correct)`

*Correct Answers:*

- `D`

**Problem 32.**
You are near the horizon of a massive black hole. The stars in the sky appear to be bluer than their natural colors, owning to

- A. the gravitational acceleration (increase in speed) of light toward the black hole.
- B. the Lorentz length contraction of the distances to the stars.
- C. the effect of the strong tidal forces on your perception of color.
- D. the gravitational Doppler shift of light toward the black hole.

*Answer submitted:*

- `D (correct)`

*Correct Answers:*

- `D`

**Problem 33.**
You are at rest near the horizon of a black hole, and a friend of yours is a large distance away. You get a good look at each other's clocks.

- A. You see your friend's clock ticking faster than yours, and she sees your clock ticking more slowly than hers.
- B. You see your friend's clock ticking more slowly than yours, and she sees your clock ticking faster than hers.
- C. You each see the other's clock ticking faster than your own.
- D. You each see the other's clock ticking more slowly than your own.

*Answer submitted:*

- `A (correct)`

*Correct Answers:*

- `A`

**Problem 34.**
You are at rest in a part of space far from any strong gravitational fields, and a friend of your flies past at 0.99 times the speed of light. You get a good look at each other's clocks as she passes by.

- A. You see your friend's clock ticking faster than yours, and she sees your clock ticking more slowly than hers.
- B. You see your friend's clock ticking more slowly than yours, and she sees your clock ticking faster than hers.
- C. You each see the other's clock ticking faster than your own.
- D. You each see the other's clock ticking more slowly than your own.

*Answer submitted:*

- `D (correct)`

*Correct Answers:*

- `D`

**Problem 35.**

A cubical spaceship, 1 km on a side flies past you, traveling parallel to one of its edges, at a speed close to that of light. It looks like

- A. still 1 km on a side crosswise to motion, but squashed to a much smaller length along its direction of motion.
- B. a long, skinny, square tube stretched out much longer than 1 km along its direction of motion.
- C. a cube much larger than 1 km on a side.
- D. a cube much smaller than 1 km on a side.

*Answer submitted:*

- A (correct)

*Correct Answers:*

- A

**Problem 36.**

A certain bright star has mass 7.8e+33 gm. In solar masses, its mass is _____

*Answer submitted:*

- 3.92 (correct)

*Correct Answers:*

- 3.91959798994975

**Problem 37.**

If you were in orbit with this circumference around a black hole, and looked straight in your direction of travel with a telescope, you'd see the back of your head:

- A. 1 horizon circumference.
- B. 1.5 horizon circumferences.
- C. 3.0 horizon circumferences.
- D. 1.0001 horizon circumferences.

*Answer submitted:*

- B (correct)

*Correct Answers:*

- B

**Problem 38.**

A certain bright star has luminosity 2.6e+34 erg/sec. In solar luminosities, its luminosity is _____

*Answer submitted:*

- 6.796 (correct)

*Correct Answers:*

- 6.84210526315789

**Problem 39.**

Select all the correct statements from the following list.

What quantities, considered absolute in classical physics, were treated as relative by Einstein?

- A. Luminosity.
- B. Gravity.
- C. Time.
- D. Velocity.
- E. The Michelson-Morley experiment.
- F. The absolute interval.
- G. Distance.
- H. Simultaneity.
- I. The speed of light.

*Answer submitted:*

- ( C, G, H ) (correct)

*Correct Answers:*

- CGH

**Problem 40.**

I travel in a straight line toward a very massive black hole, between circles centered on the black hole that have circumference 87 ly and 29 ly. The smaller circle is just barely outside the event horizon. I measure the distance I've traveled to be 13 ly. What would the distance appear to be to you, watching from a safer distance?

- A. $87\,\text{ly} - 29\,\text{ly} = 58\,\text{ly}$, longer than I measure.
- B. Zero ly, because you're so far away.
- C. $\frac{87\,\text{ly} - 29\,\text{ly}}{2\pi} = 9.2\,\text{ly}$, shorter than I measure.
- D. 13 ly, the same as I measure.

*Answer submitted:*

- C (correct)

*Correct Answers:*

- C