ASTR 1120-001 Midterm 2

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SECOND MID-TERM EXAM MARCH 21st 2006: Closed books and notes, 1 hour. Please PRINT your name and student ID on the places provided on the scan sheet. ENCODE your student number also on the scan sheet.

Questions 1-10 are TRUE / FALSE, 1 point each. Mark (a) True, (b) False on scan sheet, using a number 2 pencil.

1. The speed of light depends upon the velocity of the light source relative to the observer. FALSE
2. A clock moving at high speed relative to an observer appears to run slow. TRUE
3. The General Theory of Relativity includes the effects of gravity. TRUE
4. An accelerating observer feels heavier in exactly the same way as if the strength of gravity had increased. TRUE
5. Neutron stars and black holes are compact objects which have event horizons. FALSE
6. Radiation that escapes to large distances from very near the event horizon is shifted to higher energies. FALSE
7. Supermassive black holes are commonly found in the spiral arms of galaxies such as the Milky Way. FALSE
8. The center of the Milky Way is hard to observe in visible radiation due to obscuration by intervening gas and dust. TRUE
9. Hawking radiation is only observed for supermassive black holes. FALSE
10. The Sun will eventually explode as a supernova, leaving behind a stellar mass black hole. FALSE

Questions 11-50 are MULTIPLE CHOICE, 1 point each. Mark scan sheet with letter of the BEST answer, using a number 2 pencil.

11. Which star or stellar remnant has the largest radius:

    (a) A red giant
    (b) A main sequence star such as the Sun
    (c) A white dwarf
    (d) A neutron star
    (e) A stellar mass black hole

12. The density of matter in which star or stellar remnant is the highest:

    (a) A red giant
    (b) A main sequence star such as the Sun
    (c) A white dwarf
    (d) A neutron star

13. A flashing red light (like a bicycle rear light) falls into a black hole. As seen by an observer stationed at a safe distance, the light:

    (a) Appears to flash faster and faster as it approaches the event horizon
    (b) Becomes bluer as the event horizon is approached
    (c) Becomes very blue once the light has crossed the event horizon
    (d) Is shifted to the infrared part of the spectrum as the event horizon is approached

14. Gamma ray bursts originate:

    (a) From neutron stars in our galaxy
    (b) From white dwarfs
    (c) From pulsars
    (d) From black holes in our galaxy
    (e) From extremely distant galaxies

15. We believe that the compact star in some binary systems – such as Cygnus X-1 – is a black hole rather than a neutron star because:

    (a) We have proof of the existence of an event horizon
    (b) We infer than the mass exceeds the maximum mass a neutron star can have
    (c) We observe pulsed emission indicating the black hole is rotating
    (d) We observe gamma-ray emission
    (e) Very rapid variability implies the compact object is extremely small

16. When a star becomes a red giant, its luminosity:

    (a) Increases
    (b) Decreases
    (c) Stays approximately the same

17. A pulsar is:

    (a) A star like the Sun subject to pulsational instability
    (b) A type of white dwarf
    (c) A rotating black hole
    (d) A binary containing two black holes
    (e) A type of neutron star

18. Astronauts in the Space Shuttle feel weightless because:

    (a) Of the vacuum in space
    (b) The Space Shuttle moves in a straight line while in orbit
    (c) There's no gravitational force from the Earth acting on the Space Shuttle
    (d) The Space Shuttle is free falling while in orbit

19. If you stand on weighing scales in an elevator, your weight varies noticeably depending upon:

    (a) The velocity of the elevator
    (b) The acceleration of the elevator
    (c) The height of the elevator above ground level

20. General Relativity does *not* predict:

    (a) Length contraction
    (b) Time dilation in a strong gravitational field
    (c) Light bending
    (d) Black holes
    (e) That mass curves spacetime

21. Which of the following is *not* relative in the Special Theory of Relativity:

    (a) Intervals of time
    (b) Motion
    (c) Lengths
    (d) The speed of light

22. Catherine is moving in a spaceship past you at a speed close to the speed of light. According to *her*, while 1 minute passes for her, how much time passes for you?

    (a) 1 minute
    (b) less than 1 minute
    (c) more than 1 minute

23. The Galactic Center lies about 30,000 light years away from the Earth. Despite this great distance, the Special Theory of Relativity predicts that:

    (a) We could (in principle) send a signal to a civilization at the Galactic Center and receive an answer within a human lifetime.
    (b) An astronaut in a sufficiently fast spaceship could reach the Galactic Center and return within their (the astronaut's) lifetime.
    (c) We could send a sufficiently fast robotic spaceship on a round trip to the Galactic Center, and get a sample back within our lifetime.

24. The effects predicted by Special Relativity are not normally noticed in everyday life because:

    (a) Everyday velocities are small compared to the speed of light
    (b) The Earth's gravity is extremely weak
    (c) The Earth is free falling as it orbits the Sun
    (d) Typically we experience only very small accelerations
    (e) The Earth is not an inertial frame, so Special Relativity does not apply

25. The Principle of Equivalence can be stated as:

    (a) The results of experiments conducted by moving observers are equivalent
    (b) The effects of gravity and acceleration are equivalent
    (c) Experiments conducted by accelerating observers are equivalent to those carried out by stationary observers
    (d) The effects of velocity and gravity are equivalent

26. The General Theory of Relativity predicts that:

    (a) A clock near a black hole appears to run fast
    (b) Light is deflected in a gravitational field
    (c) The event horizon of a black hole emits extremely weak radiation
    (d) Virtual particles can be temporarily created out of nothing

27. The formula for the escape velocity from a planet of mass M and radius R is $v = \sqrt{2GM/R}$. A consequence of this formula is that:

    (a) More massive planets necessarily have higher escape velocity than lower mass planets
    (b) If two planets have the same radius but one has twice the mass, the more massive planet has twice as large an escape velocity
    (c) If two planets have the same mass but one has a smaller radius, the planet with the smaller radius has a lower escape velocity
    (d) If two planets have the same mass but one has a smaller radius, the planet with the smaller radius has a higher escape velocity

28. We can (in principle) learn about what's going on within the event horizon of a black hole by observing:

    (a) X-rays from the black hole system
    (b) Light escaping from inside the event horizon
    (c) Gravitational waves
    (d) The motion of stars in orbit around the hole
    (e) We cannot learn what's going on inside a black hole from outside the event horizon

29. The radius of the event horizon for a black hole with the same mass as the Sun is roughly:

    (a) 3 cm
    (b) 3 m
    (c) 3 km
    (d) 3000 km
    (e) 3 light years

30. An astronaut is unfortunate enough to fall toward a very large black hole. From their point of view they:

    (a) Fall in until he or she approaches the event horizon, at which point time slows down and they freeze there for eternity
    (b) Fall through the event horizon without noticing anything special at that moment
    (c) Are ripped apart by the gravity of the black hole at the event horizon
    (d) Can communicate with an observer outside the event horizon until they reach the singularity.

    (*for the purposes of this question, assume that the black hole is large enough that tidal forces are negligible. If you don't know what tidal forces are, don't worry!)*

31. The strongest observational evidence for the existence of black holes concerns holes with a mass comparable to:

    (a) The mass of a subatomic particle
    (b) The mass of the Earth
    (c) 1 Solar mass
    (d) 10 Solar masses
    (e) 10,000 Solar masses

32. Where in the Milky Way galaxy is the Sun located:

    (a) In the disk
    (b) In the bulge
    (c) In the halo
    (d) Close to the supermassive black hole
    (e) In the cluster

33. The presence of supernova remnants near the Galactic Center is evidence that:

    (a) Massive stars formed there recently
    (b) Low mass stars like the Sun formed there recently
    (c) There is a black hole at the Galactic Center
    (d) Dust obscures our view of the Galactic Center
    (e) There are white dwarf stars in the Galactic Center

34. As we look at stars closer and closer to the exact center of the Milky Way galaxy, the velocities of the stars:

    (a) Decrease
    (b) Stay the same
    (c) Increase

35. Adaptive optics is a technique used:

    (a) To correct images taken by the Hubble Space Telescope
    (b) To overcome the effect of dust obscuration toward the Galactic Center
    (c) To mitigate the distortion caused by the Earth's atmosphere
    (d) To improve the resolution of radio telescopes
    (e) To allow the accurate measurement of apparent brightness

36. As a consequence of Hawking radiation, the radius of the event horizon of a small black hole is predicted to:

    (a) Slowly decrease
    (b) Slowly increase
    (c) Remain always constant

37. A red giant star is:

    (a) Much younger than the Sun
    (b) Much hotter than the Sun
    (c) Smaller than the Sun
    (d) Much larger in radius than the Sun
    (e) Denser than the Sun

38. The ultimate fate of the core of a star similar to the Sun is thought to be:

    (a) A white dwarf
    (b) A neutron star
    (c) A planetary nebula
    (d) A supernova remnant
    (e) A pulsar

39. Massive stars – with masses greater than about 8 times the mass of the Sun:

    (a) Have lower luminosities than the Sun
    (b) Form planetary nebula when they come to the end of their lives
    (c) Always end up as black holes
    (d) Have much shorter lifetimes than the Sun
    (e) Have much longer lifetimes than the Sun

40. A planetary nebula is:

    (a) A stage in the evolution of a star like the Sun
    (b) A disk from which planets form
    (c) Formed in a supernova explosion
    (d) A dark cloud from which new stars form
    (e) Associated with gamma-ray bursts

41. A supernova explosion can outshine a whole galaxy for:

    (a) A fraction of a second
    (b) A day
    (c) A few months
    (d) A thousand years
    (e) Millions of years

42. Supernova explosions occur within our own galaxy (the Milky Way):

    (a) About once a day
    (b) About once a year
    (c) About once every 100 years
    (d) About once every million years
    (e) No supernova has ever occurred within the Milky Way

43. Pulsars were originally detected by Jocelyn Bell via observations of:

    (a) The Crab Nebula
    (b) Cygnus X-1
    (c) Sgr A^*
    (d) X-ray emission
    (e) Radio emission

44. The pulsations from pulsars occur because:

    (a) The neutron star is oscillating with a regular period
    (b) The neutron star is rotating
    (c) Gas is spiraling in toward the star through an accretion disk
    (d) The compact star is orbiting in a close binary system

45. Planetary systems are known to exist:

    (a) Around most pulsars
    (b) Around one pulsar, with an unknown formation mechanism
    (c) Around pulsars whose progenitor stars had planetary systems
    (d) Around pulsars in binary systems

46. Most neutron stars:

    (a) Are found in close binary systems
    (b) Are observed at the center of supernova remnants
    (c) Are isolated in space and hard to detect
    (d) Are very luminous X-ray sources

47. It is possible to infer the mass of the compact star (neutron star or black hole) in systems such as Cygnus X-1 because:

    (a) Masses can sometimes be determined from observations of binary stars
    (b) X-ray observations permit measurement of the mass of the accreting star
    (c) Radio pulsations allow a measurement of the stellar rotation period
    (d) The luminosity increases with increasing mass

48. Gamma-ray bursts are observed to originate:

    (a) From close to the center of the Milky Way
    (b) From a thin disk coincident with the stellar disk of the galaxy
    (c) From neutron stars in the halo of the galaxy
    (d) From random locations across the whole sky
    (e) From the Sun

49. A pair of neutron stars in a close binary system eventually merges due to:

    (a) Mass transfer between the stars via an accretion disk
    (b) Loss of energy as the pulsars spin down
    (c) X-ray radiation
    (d) Gravitational waves which carry away energy
    (e) Hawking radiation

50. Those gamma-ray bursts with longer durations (10s of seconds) are though to arise from:

    (a) The merger of binary neutron stars
    (b) The collapse of the cores of very massive stars
    (c) The merger of a black hole with a neutron star
    (d) Planetary nebulae
    (e) Their origin remains a complete mystery