

PHYSICS 7 MIDTERM #2

Dec. 10

Instructor: J. Wudka.

1. Einstein's theories of relativity replaced Newton's because

(a) Newton's were old and people felt a more modern view was needed

(b) Most people *felt* Einstein's was nicer

(c) Newton's theories were based on religious beliefs which were no longer valid in the early 20th century

(d) Most advocates of Newton's theories died

(e) They provide a better description of the experimental data

2. Light leaving the surface of a massive star will

(a) Decelerate due to the gravitational pull

(b) Be redder (when detected in outer space) than what it was on the surface

(c) Accelerate to speeds faster than light

(d) Have a very short wavelength: since light moves very fast the wavelength is shortened to almost zero due to length contraction

(e) Have the same wavelength as on the surface

3. Gravitational waves

(a) Move at the speed of sound

(b) Have been proved to be an incorrect prediction of the Special Theory of Relativity

(c) Move at the speed of light

(d) Move at infinite speed

(e) Are created *only* by black holes

4. The basic idea for determining distances to luminous objects up to 10^9 light years is to

(a) Use a very very long ruler

(b) Wait until space travel is sufficiently advanced to go there

(c) Infer the brightness near by, to measure the brightness on Earth and then use the $1/(\text{distance})^2$ rule

(d) Use the bending of light to determine the mass of the object and then calculate the orbits using Newton's theory. Then the orbits are observed from Earth and these data determine the distance

(e) Use the fact that light, unlike sound, is not Doppler shifted

5. A star is observed in planet X, it is also observed in planet Y which is 20 times farther from the star than planet X. In Y the star will be

(a) 20 times brighter than on X

(b) Just as bright as on X

(c) 400 times dimmer than on X

(d) 20 times dimmer than on X

(e) 40 times brighter than on X

6. The statement that mass and energy are equivalent implies that

(a) Gravitational mass is different from inertial mass

(b) One can be transformed into the other

(c) Mass is conserved

(d) Space and time are unaffected by energy

(e) Space and time are affected only by very large masses

7. The expansion of the universe is

- (a) Enhanced by the presence of matter
- (b) Indifferent to the presence of matter
- (c) Suppressed by the presence of matter but enhanced by the presence energy
- (d) Suppressed to a greater or lesser degree depending on the amount of matter and energy
- (e) Suppressed by the presence of energy but enhanced by the presence matter

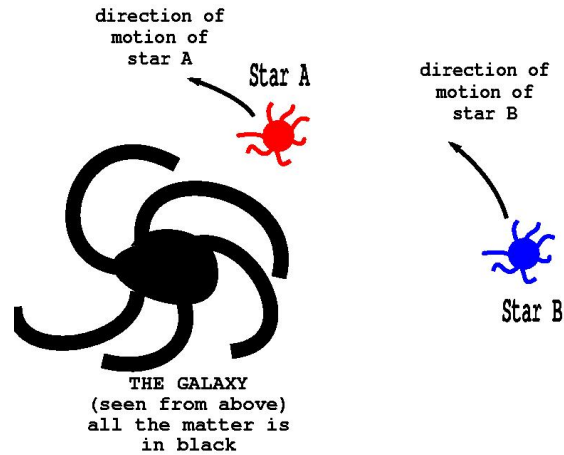
8. The heavy elements are

- (a) Created during the Big Bang
- (b) Destroyed by all stars
- (c) Destroyed during the Big Bang
- (d) Product of human activity
- (e) Created by stars

9. Tank Woman goes to a neutron star to retrieve a lost CD,

- (a) When she returns she will have aged more than her twin
- (b) When she returns she will have aged less than her twin
- (c) When she returns she will be as old as her twin
- (d) She must then stay forever: no light leaves a neutron star
- (e) She can then leave only in the form of an X-ray (cool!)

10. Suppose you know all the matter in a galaxy is concentrated in a central region. Two stars move around this galaxy as in the drawing below



Then

- (a) Star A moves just as fast as star B
- (b) Star A moves slower than star B
- (c) Star A will fall to the galaxy
- (d) Star A moves faster than star B
- (e) Star B will fall to the galaxy

11. A Cepheid variable is useful in determining distances because

- (a) Their strong X ray emissions are well known
- (b) They easily out-shine a galaxy and can be seen from very far
- (c) They represent gas clouds and so we can use them to determine the distance to the places where stars are born
- (d) They brighten periodically and their period determines their brightness
- (e) They *all* the same constant brightness

12. Imagine a big red giant star which is slowly turning around on its axis. After a while the star contracts and will

- (a) Slow down its spinning motion
- (b) Keep the same spinning motion
- (c) Stop spinning
- (d) Speed up its spinning
- (e) Reverse its direction of rotation

13. H.G. Wells writes a science fiction story in which everything happens in a universe where time is absolute. Then in this universe

- (a) The speed of light would be relative
- (b) The speed of light would be absolute
- (c) Time would be relative
- (d) Simultaneity would be relative
- (e) None of the above

14. The statement that the speed of light is absolute means that

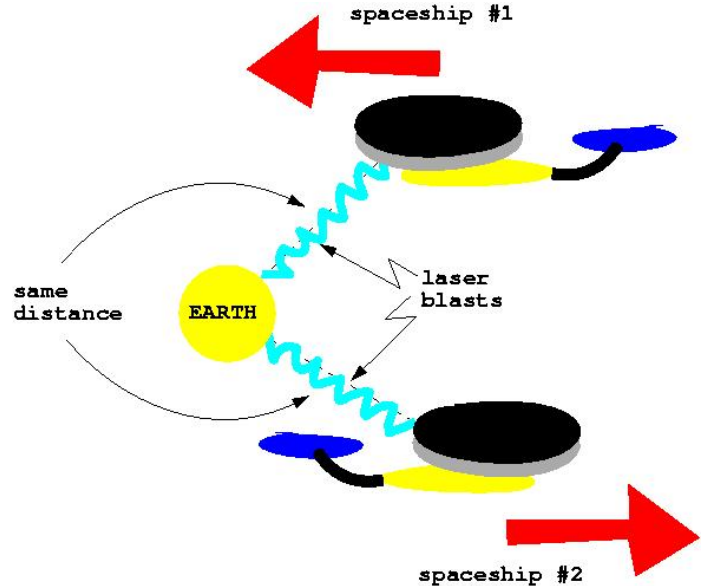
- (a) It has the same value for all observers
- (b) That it is accelerated by gravity
- (c) That it is slowed down by gravity
- (d) That it changes according to the motion of the source
- (e) That all light came from the Big Bang

15. An observer on a galaxy far from us will see

- (a) Some far galaxies receding, but some others approaching
- (b) All far galaxies being blueshifted
- (c) The Milky Way receding, but all other far galaxies approaching
- (d) All far galaxies receding from him/her/it

(e) All galaxies except the Milky way stationary

16. Two spaceships are moving relative to one another as in the drawing below. When they are at the same distance from Earth each sends a blast of laser light.



The two light beams

- (a) Reach Earth at the same time
- (b) The beam of the spaceship moving towards Earth reaches us first
- (c) The beam of the spaceship moving away from Earth reaches us last
- (d) The beam of the spaceship moving towards Earth reaches us last
- (e) The beam of the spaceship moving away from Earth reaches us first

17. Stellar cores collapse due to the

- (a) External pressure produced by the surrounding gas
- (b) Degenerate electron pressure of the electrons in the outer layers of the star
- (c) Absence of gravity to balance the inward pressure

- (d) Absence of a pressure which can balance gravity
- (e) Equality of gravitational and inertial masses

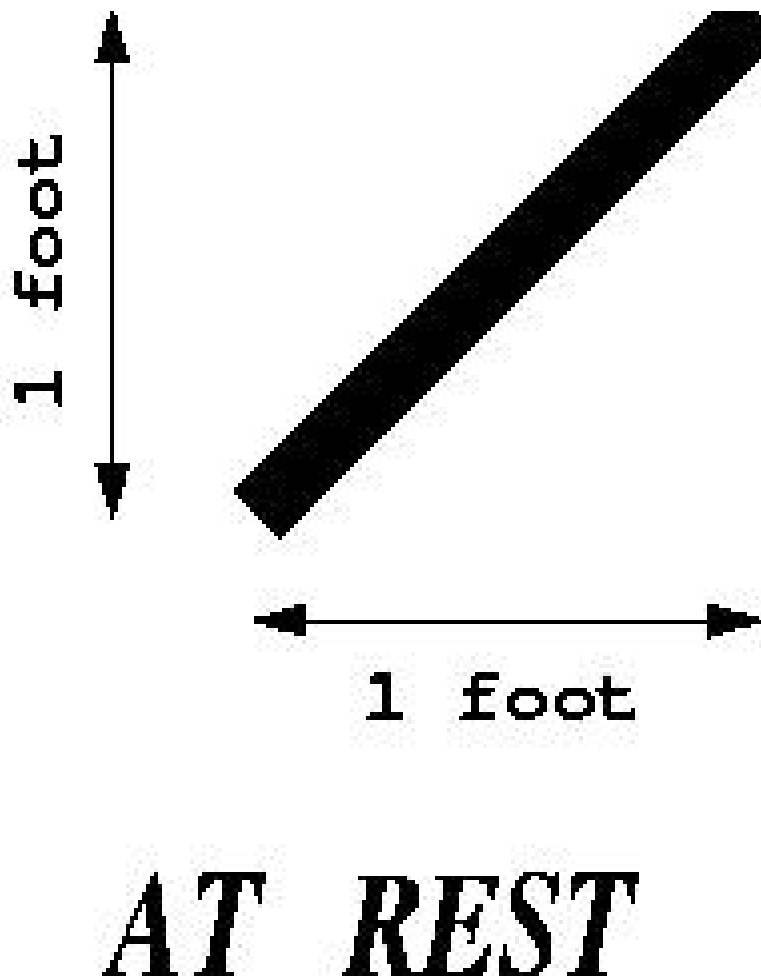
18. A box full of a very hot hydrogen gas moves with respect to Earth. Using the emission lines received from such a box one can determine

- (a) The force of gravity exerted by the Earth
- (b) The speed of light
- (c) The speed of the box
- (d) The bending of light by the Earth
- (e) The difference between inertial and gravitational masses

19. Light

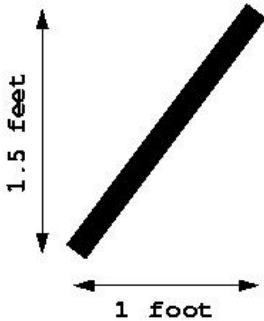
- (a) Needs the ether to propagate
- (b) Needs some transparent material such as air or water in order to propagate
- (c) In outer space travels at different speeds in different directions
- (d) In outer space travels at different speeds in different places
- (e) Does not need any medium to propagate

20. A tilted stick at rest looks like this

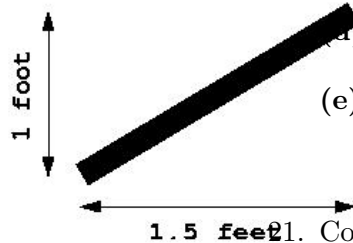


Consider now the following possibilities corresponding to the same stick moving at a constant large speed to the right

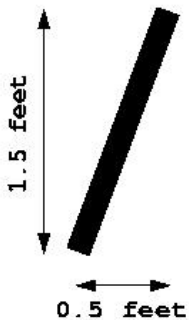
DIRECTION OF MOTION



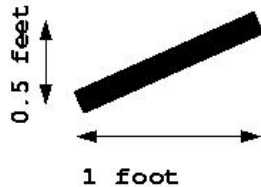
(a)



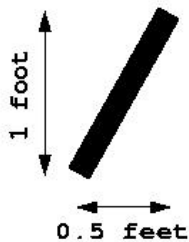
(b)



(d)



(c)



(e)

According to the Special Theory of Relativity the stick will actually look like

(a) Figure a

(b) Figure b

(c) Figure c

(d) Figure d

(e) Figure e

21. Count Dracula dresses in red and flies out to hunt. Peggy is on a night pick nick at the cemetery and is noticed by Count D. who flies at her with amazing speed. Before she is bitten she will

(a) See a red bat

(b) See a black bat

(c) See a blue bat

(d) See the Count's watch tick faster than her own

(e) See him fly backwards

22. Two heavyweight lifters weigh the same on Earth. They are taken into outer space where one is heated and the other is not (now you have one very hot heavyweight and one very cold heavyweight).

(a) Each affects the curvature of space in precisely the same way

(b) The hot one affects the curvature of space more as it has more energy

(c) The cold one affects the curvature of space more

(d) They do not affect the curvature of space at all

(e) The cold affects the curvature of space but the hot one does not

23. A train moving at large speed with respect to a platform. A person sitting in the middle of a wagon states that at one point two waiters came into the wagon and simultaneously slipped and fell. As seen from the platform
- (a) The waiter at the front of the wagon fell first
 - (b) The waiters fell simultaneously
 - (c) The waiter at the front of the wagon did not fall
 - (d) The waiter at the back of the wagon fell first
 - (e) The waiter at the back of the wagon did not fall
24. The Big Bang theory
- (a) Cannot explain the abundances of any element
 - (b) Does not predict the microwave radiation but explains the abundances of heavy elements such as Uranium
 - (c) Predicts the abundances of light elements
 - (d) Is based on a big nuclear explosion
 - (e) Assumes that the initial blast was produced by nuclear fusion
25. The Big Bang description of the universe predicts that
- (a) The farthest galaxies move away slower
 - (b) All galaxies are seen to move away from the Milky Way at the same speed
 - (c) Only near galaxies move away, the far galaxies approach the Milky way
 - (d) All galaxies are stationary but the space is expanding
 - (e) The farther a galaxy is from the Milky Way, the faster it will move away from it
26. One particularly important verification of the idea that electron degenerate pressure is responsible for the stability of white dwarfs is
- (a) The fact that they all become supernovas
 - (b) The fact that they are the opposite of black holes: they expel everything
 - (c) They always have a mass above 3 solar masses
 - (d) They always have a mass below 1.4 solar masses
 - (e) They are larger than a red giant
27. In planet Zorg a seed is planted and, at the same time, in planet Groz a tree dies. From a moving spaceship
- (a) The order in which these events are seen to happen depends on the direction of motion
 - (b) The order in which these events are seen to happen is independent of the ship's motion
 - (c) The seed planting always occurs first (independent of the ship's motion)
 - (d) The death of the tree always occurs first (independent of the ship's motion)
 - (e) The two events occur at the same time (independent of the ship's motion)
28. The background microwave radiation is
- (a) The remnants of a big alien microwave oven
 - (b) Generated by the stars in our galaxy
 - (c) The redshifted radiation from the early universe
 - (d) The blueshifted radio waves produced by distant quasars
 - (e) An unverified prediction of the Big Bang theory
29. A black hole horizon is a region

- (a) Where all matter coming near a black hole is reflected back
- (b) Separating two parts of space that cannot communicate with each other
- (c) Where the speed of light is infinite
- (d) Separating us from a part of space to which matter cannot go
- (e) Where light stops

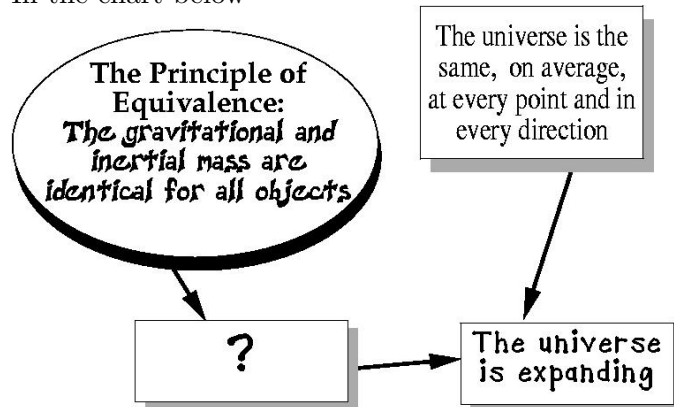
30. When a magnet is moved into and out of a coil in a regular manner it generates a current. If the principle of relativity is correct then when the magnet is held and the coil is moved (again in a regular manner) the result would be

- (a) the same: a current is induced
- (b) null: no current would occur
- (c) a current at first but then it would die out
- (d) a current which steadily increases
- (e) that the magnet loses its magnetism

31. Lizzy the lizard is sent into a black hole, as it approaches the horizon Earth's telescopes we will see

- (a) Lizzy becoming bluer and rapidly aging
- (b) Lizzy becoming redder and moving more and more slowly
- (c) Lizzy becoming younger and then turning into an egg and then vanishing in a puff of purple smoke
- (d) Nothing: all light close to the horizon is sucked into the black hole
- (e) Lizzy just as green as ever and moving as dejectedly as before

32. In the chart below



the statement that belongs in the box with the question mark is

- (a) There is no ether
- (b) The speed of light is absolute
- (c) The speed of light is relative
- (d) The universe does not expand
- (e) Gravity curves space

33. Within the Special Theory of Relativity the adjective "relative" means

- (a) *Dependent* on the state of motion of the observer
- (b) Having the same gravitational and inertial masses
- (c) Not associated with light
- (d) Pertaining the velocity of light
- (e) *Independent* of the state of motion of the observer

34. Mr. Uvw has a yard stick, Ms. Abc has another identical yardstick. Abc and her yardstick start moving and by now they are moving at constant speed with respect to Uvw. Then

- (a) The two yardsticks are measured by *both* Uvw and Abc to have the same length

(b) Uvw measures Abc's stick to be shorter than his, but Abc measures Uvw's to be the same length as hers

(c) Abc measures Uvw's stick to be shorter than hers, but Uvw measures Abc's to be the same length as his

(d) Both Abc and Uvw measure the *other* yardstick to be shorter

(e) Both Abc and Uvw perceive the *other* to be longer, but this is only an illusion, they *really* have the same length

35. As the sun gives off radiation it loses energy

(a) But this in no way affects the way in which it curves space

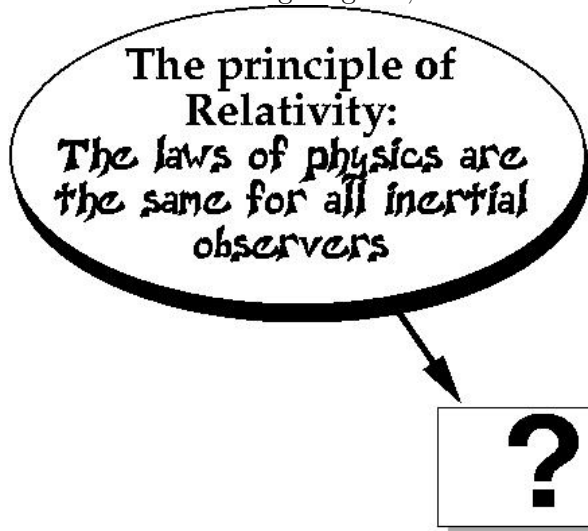
(b) And this increases its effects on the curvature of space

(c) Showing that its inertial and gravitational masses are different

(d) Which produces a larger bending of light effect

(e) And this slightly decreases the Sun's effects on the curvature of space

36. Consider the following diagram,



the appropriate text on the box with the question mark is

(a) Inertial and gravitational masses are identical

(b) The speed of light is relative

(c) Matter warps space

(d) Maxwell's equations are inconsistent

(e) The speed of light is absolute

37. You have two identical clocks which I will call *A* and *B*, and you are far from a very massive planet. Initially both clocks are perfectly synchronized. You first send *A* to the surface of the planet and then you send *B*, then you yourself go there (nothing gets physically damaged during the trips and landings). When you arrive you find that

(a) The clock *A* is slow compared to *B*

(b) The clock *B* is slow compared to *A*

(c) Both clock are ticking *backwards*

(d) Both clocks have stopped

(e) Both clock are synchronized

38. The equivalence principle states that

(a) Inertial mass is unobservable

(b) Inertial and gravitational masses are identical

(c) The gravitational mass is always larger than the inertial mass

(d) All bodies respond in the same way to *all* forces

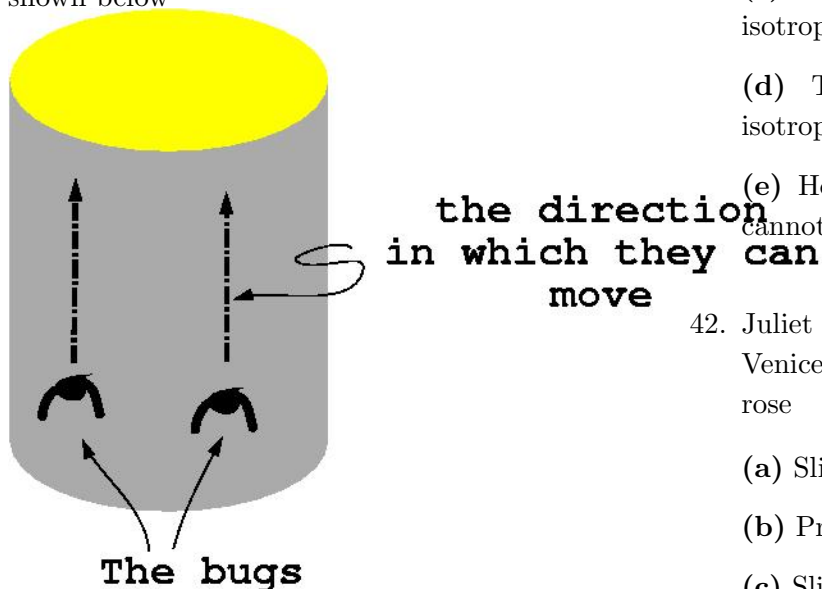
(e) The acceleration of a body is the same as its speed

39. Given the following abbreviations, A=average star, B=black hole, G=gas cloud, N=neutron star, R=red giant, S=supernova, W=white dwarf, a possible evolution sequence for a star is

(a) A-B-G-N

- (b) A-B-S-G
- (c) G-A-N-S
- (d) G-A-S-B
- (e) G-A-B-S

40. Two bugs are mandated to move on a cylinder as shown below



Assume that the bugs can move *only* in the direction shown, and that the cylinder is so long that they will die before reaching the end-caps. Then

- (a) They can determine that their space is curved since they will be closer to each other after a time
- (b) They cannot determine whether their space is curved or not
- (c) The bug on the left will realize their space is curved but the one on the right will not
- (d) The bug on the right will realize their space is curved but the one on the left will not
- (e) They can determine that their space is curved since they will be farther apart after a time

41. Suppose you take a jar and fill it with fine sand and water. Then you shake the jar so that the sand is suspended in the water (at least for a while). While

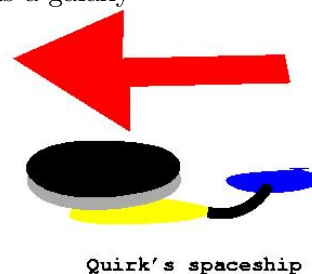
the sand is still suspended imagine that you can observe this water+sand mix from a point in the center of the jar. Then

- (a) The system will look isotropic but not homogeneous
- (b) The system will look homogeneous but not isotropic
- (c) The system will look neither homogeneous nor isotropic
- (d) The system will look homogeneous and isotropic
- (e) Homogeneity and isotropy are concepts that cannot be applied to this system

42. Juliet is on a very tall tower (she is on a trip to Venice, Italy) and has a red rose. Romeo sees this rose

- (a) Slightly redder
- (b) Precisely the same color as Juliet
- (c) Slightly more yellow
- (d) Only if he can detect radio waves
- (e) Only if he can detect microwaves

43. Capt. Quirk travels in space at a constant *acceleration* towards a galaxy



according to his sensors the size of the galaxy

- (a) Is continuously decreasing
- (b) Is constant
- (c) Cannot be measured
- (d) Increases and then decreases
- (e) Decreases and then increases

44. A person sits in a closed box in outer space, for a few minutes he feels pressed against the floor of the box, after that he floats inside the box. A possible explanation is that the box

- (a) Was first accelerated, then decelerated to zero speed and is now at rest
- (b) Was first accelerated, then the acceleration stopped, and the box then continued moving at constant speed
- (c) Has always moved at the same constant speed
- (d) Has always been accelerating
- (e) First moved at constant speed and accelerated while he was floating inside

45. The statement *time is relative* means that

- (a) Time intervals depend on the state of motion of the observer
- (b) Time intervals are independent of the state of motion of the observer
- (c) Light become redder as the source approaches the observer
- (d) Time is absolute
- (e) We cannot measure time accurately

46. A massive black hole lies between Earth and a very bright star; both star and black hole are perfectly spherical. Astronomers on Earth see

- (a) Nothing: the black hole blocks all light from the star
- (b) A circle of light composed of images of the star
- (c) A double image of the star
- (d) A quadruple image of the star
- (e) An infinitely bright star

47. The precession of the orbits predicted by General Relativity is

- (a) An effect peculiar to Mercury due to its chemical composition
- (b) An effect only present for very massive objects such as the double pulsar
- (c) Most noticeable in Mercury but present in *all* planets
- (d) One of the unverified predictions of this theory
- (e) Produced by dust

48. Measuring distances to near star using parallax relies on

- (a) The $1/(\text{distance})^2$ rule
- (b) The emission and absorption lines
- (c) Geometry, and the knowledge of the size and shape of Earth's orbit
- (d) The periodic brightening of *all* stars (which we know as twinkling)
- (e) The fact that light bends around the sun

49. We do not experience time dilation because this effect

- (a) Is too small for ordinary speeds
- (b) Is exactly zero except at speeds very close to that of light

- (c) Is exactly zero except near black holes
- (d) Was proved wrong by Newton
- (e) Was proved wrong by Einstein

50. You have a rigid disk and a can, the can has no top and the disk has a diameter very slightly larger than the can's. If you now make the disk rotate very rapidly

- (a) Its diameter will increase and so it will still not fit
- (b) Its circumference will increase and it will not fit
- (c) Its circumference will increase and its radius decrease and it will be ripped apart (and then you can cut the pieces inside the can)
- (d) *Both* the circumference and the radius will decrease and it will fit in the can
- (e) The circumference is contracted but the radius is unaffected, the disk bulges and you can fit it in the can

51. Aliens

- (a) Have never been on Earth
- (b) Came close to Earth but our violence frightened them away
- (c) Have been on Earth, but they come just to burn circles in corn crops
- (d) Have been on Earth, but they come here just to collect specimens for their zoos
- (e) *Are* on Earth...in fact they have taken over!

NAME and SS#:_____

**Provide short (coherent) answers to the following questions (yes/no answers are not acceptable).
Use this sheet and the back of the page**

1. Fred has two clocks, one is the light-pulse clock and the other is a rollex. Mary also has two similar clocks. Fred is moving at constant speed with respect to Mary yet their rollexes *remain synchronized*. Explain how this can be used to detect absolute motion (This is a hypothetical scenario not realized in our universe)
2. The Big Bang theory predicts that the universe is expanding. Does this mean that *all* the light we receive from all the stars and galaxies is necessarily shifted towards the red? Explain your answer (concisely)
3. Where did the Big Bang happen? Explain your answer (concisely)