Clicker Questions

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25 Science, Philosophy, and the Big Questions
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Question 1

Question

Which year are you in?

A. Freshman
B. Sophomore
C. Junior
D. Senior
E. Other

Question 2

Question

Why did you take this class?

A. I always wanted to know more about Einstein and the relativity and quantum revolutions.

B. Out of curiosity.

C. Someone recommended the class to me.

D. The course description sounded really cool (on course listings/website).

E. Other.

Question 3

Question

What is your major?

A. in arts and humanities
B. in natural sciences
C. in social sciences
D. in engineering
E. other or undeclared

Question 4

Question

We have seen that in special relativity, the speed of light is the same for all uniformly moving observers. What consequences does this have for our measurements of space and time?

A. None.

B. Time runs faster, space shrinks for moving observers.

C. Time runs slower, space shrinks for moving observers.

D. Time runs faster, space expands for moving observers.

E. Time runs slower, space expands for moving observers.

Question 5

Question

Suppose you are a two-dimensional being living on a two-dimensional sphere. How could you find out that you live in a curved space?

A. I could travel along a line to see whether I return to my vantage point.

B. I need a twin sibling to send her/him on a fast-paced trip, at the end of which we compare our watches.

C. I use the fact that in curved spaces, the sum of the interior angles of triangles does not add up to 180 degrees.

D. I cannot find it out.

Question 6

Question

How does general relativity permit time travel?

A. It allows acceleration to superluminal speeds.

B. It allows strange topologies, including time loops.

C. It allows discontinuous worldlines of material objects.

D. It allows backward-in-time causation.

Question 7

Question

Which one of the following is not an inertial motion?

A. forward motion at uniform speed in a circle
B. forward motion at uniform speed in a line
C. backward motion at uniform speed in a line
D. rest

Question 8

Question

According to Norton what is a better slogan than 'All motion is relative'?

A. 'All acceleration is relative'
B. 'All relative motion is relative'
C. 'All absolute motion is relative'
D. 'All rest is relative'

Question 9

Question

Which of the following is the correct formulation of the principle of relativity?

A. All observers at rest find the same laws of physics.

B. All observers in relative motion find the same laws of physics.

C. All inertial observers find the same laws of physics.

D. All observers find the same laws of physics.

Question 10

Question

Suppose a light clock is set into rapid motion perpendicular to the rod of the clock. Comparing this light clock to one at rest, which of the following statements is not true of the moving light clock?

A. It will take the light signal longer to reach the far end.

B. The length of the rod of the clock is contracted.

C. The speed of light remains the same.

D. The light signal will cover a larger distance before it reaches the far end.

Question 11

Question

Which of the following is a false statement regarding motion in special relativity?

A. The speeds of objects are divided into three groups (slower than, equal to, faster than the speed of light), independently of which observer looks at them.

B. We cannot slow down or speed up anything so that it crosses the barrier of the speed of light.

C. If we keep adding speeds according to Einstein's rule, we will eventually reach speeds higher than that of light.

D. The principle of relativity prohibits that a particle is faster than light for one observer, but slower than light for another.

Question 12

Question

If two velocities of 100,000 miles per second are added relativistically, what is the result?

A. velocities cannot be added if their sum would exceed the speed of light

B. 155,000 miles per second

C. 186,000 miles per second

D. 200,000 miles per second

Question 13

Question

Which of the following is not an important assumption in our statement of the relativity of simultaneity?

A. That the two clocks at the platform's ends are properly synchronized for all observers.

B. That both observers move inertially.

C. That light moves at the same speed in all directions.

D. That the stationary observer is located at the midpoint of the platform.

Question 14

Question

The relativity of simultaneity in special relativity is not...

A. the simple disagreement on the simultaneity of events of different observers located in different places.

B. the appearance to us now of an event long past.

C. an important basic effect in special relativity.

D. our inability to synchronize spatially distant clocks.

Question 15

Question

What is the thought experiment with the car and the garage supposed to illustrate?

A. That moving rods shrink and that moving clocks tick more slowly.

B. That simultaneity is relative.

C. That the principle of relativity seems to lead to an inconsistency (both the car is fully trapped within the garage and it is not).

D. That the looming inconsistency is no more serious than simple perspectival effects.

Question 16

Question

How do kinematics and dynamics differ from one another?

A. Kinematics is concerned with motion, dynamics with its causes.

B. Dynamics is concerned with motion, kinematics with its causes.

C. Kinematics is concerned with forces, dynamics with their causes.

D. Dynamics is concerned with forces, kinematics with their causes.

Question 17

Question

If a constant force acts on a body, the momentum gained by the body equals the force times the distance through which force acts.

A. True

B. False

Question 18

Question

Which of the following is not an instance of momentum conservation?

A. A spacewalker pushing off an isolated spaceship in deep space.

B. Two billiard balls colliding.

C. The interactions in the thought experiment with two massive blocks approaching one another and a light ball bouncing back and forth between them.

D. All of the above are instances of momentum conservation.

Question 19

Question

$E = mc^2$ says that energy and mass are equivalent. Given the conversion factor of c^2, what do you estimate the energy equivalent of one gram of mass to be?

A. 25,000 kilowatt hours

B. 2,500,000 kilowatt hours

C. 250,000,000 kilowatt hours

D. 25,000,000,000 kilowatt hours

Question 20

Question

When physicists failed to detect the ether in the 19th century, how did they explain this fact?

A. They insisted that Young's double slit experiment showed that light consisted of waves.

B. They reverted to Newton's corpuscular theory of light.

C. They invoked Fresnel's 'ether drag' hypothesis.

D. They concluded that there was no such thing as the ether.

Question 21

Question

Why is Lorentz's assertion that all the other forces present in matter behaved exactly like electric and magnetic forces an 'ad hoc' hypothesis?

A. Because it offered a brilliant and novel insight.

B. Because it was devised merely to explain the fact at hand.

C. Because it enjoyed no independent support from anywhere else.

D. Because it is hokey.

Question 22

Question

In the thought experiment of the magnet and the conductor as presented by Norton, why does the conductor not detect an electric field when the magnet is moving?

A. Because Maxwell's electrodynamics treats a magnet moving through the ether in the same way as one at rest.

B. Because a moving magnet does not induce an electric field.

C. Because the conductor does not move relative to the magnet.

D. Because the absolute motion of the conductor through the magnet field induces a second, exactly countervailing electric current.

Question 23

Question

In emission theories of light, the velocity of light is constant with respect to

A. the source that emits the light, not the ether.

B. the ether, but not to the source it emits.

C. all inertial observers, but not the source it emits.

D. the receiving observer, not the ether.

Question 24

Question

The past light cone at an event p consists of all the events from which a light signal can reach p.

A. True

B. False

Question 25

Question

A timelike curve...

A. is the trajectory of a point moving at more than the speed of light (e.g. tachyon).

B. is the trajectory of a point moving at the speed of light.

C. is the trajectory of a point moving at less than the speed of light.

D. None of the above.

Question 26

Question

Spacelike hypersurfaces...

A. can be instantaneous snapshots of spacetime.

B. are three-dimensional (in the case of a four-dimensional spacetime).

C. can represent the set of all simultaneous events.

D. All of the above.

Question 27

Question

Drawing a tilted spacelike hypersurface representing the set of simultaneous events as judged by a moving observer, if the observer is set into motion to the right, their worldline will be titled to the right and the hypersurface of simultaneity will be tilted down on the right side.

A. True.

B. False.

Question 28

Question

Do you actually do the assigned reading before class?

A. Yes.

B. Sometimes.

C. Rarely.

D. Never.

Question 29

Question

In a relativistic (i.e., Minkowski) spacetime, there is no unique, preferred way of 'unstacking' the spacetime into hypersurfaces of simultaneity.

A. True.

B. False.

Question 30

Question

The fact that tachyons can be considered travelling backwards in time crucially depends on which principle or basic fact?

A. Principle of Relativity
B. Light Postulate
C. relativity of simultaneity
D. four-dimensional nature of spacetime

Question 31

Question

The tachyon paradoxes are troubling because...

A ... they show that backward in time travel is possible.

B ... they lead to contradictions.

C ... they violate the Light Postulate.

D ... they imply that there are no tachyons.

Question 32

Question

The 'half-twin' effects shows the symmetry of clock slowing of inertial observers moving relative to one another.

A. True.

B. False.

Question 33

Question

Which of the following is not a false conception of the twin paradox?

A. The Principle of Relativity implies that at the end of the journey the clocks of the two twins cannot disagree.

B. Both the stay-at-home twin and the travelling twin will see the other twin's clock tick fewer times over the course of the trip.

C. Given the Principle of Relativity, both observers must undergo acceleration.

D. Both twins will see the other twin's clock tick slower during the outward trip.

Question 34

Question

A timelike geodesic is the timelike curve connecting two events of...

A. smallest proper time.

B. greatest proper time.

C. smallest proper distance.

D. greatest proper distance.

Question 35

Question

Assuming that you did try to fuse the pictures of chapter 12 to obtain a stereovision of a three-dimensional objects, did you get the desired effect?

A. Yes, reliably.

B. Sometimes, but not reliably.

C. Only for brief moments.

D. No, never.

Question 36

Question

What would be the volume of a 17-dimensional cube of length L and the volume of its surface/perimeter?

A. $17L$ and $17L^{17}$

B. $17L$ and $34L^{16}$

C. L^{17} and $17L^{17}$

D. L^{17} and $34L^{16}$

Question 37

Question

Verification is the thesis that...

A. hypotheses must be verified in order to be scientific.

B. scientific hypotheses can only be verified, but never falsified.

C. hypotheses are meaningless unless they can at least be confirmed (if not verified) empirically.

D. hypotheses are meaningless unless they can be fully verified.

Question 38

Question

What did Einstein's special theory of relativity and Lorentz's electron theory agree on?

A. That there is no observably distinguishable state of rest.

B. That there is no such thing as an ether.

C. That motion through the ether causes rods to contract and clocks to slow.

D. That there is no preferred state of rest.

Question 39

Question

What is the central thesis of Bridgman's operationism?

A. Focusing on operations in a scientific context allows us to trigger more revolutions in science.

B. A concept is meaningful just up to the operations used to determine it.

C. The reason why our concepts are plagued by harmful, false assumptions is because our concepts are defined operationally.

D. To define concepts operationally allows us to absorb central assumptions of a theory into its definitions.

Question 40

Question

The two main reasons for the importance of Euclid's Elements *for our understanding of the foundations of science are its structure and the certitude of its results.*

A. True.

B. False.

Question 41

Question

The structure of Euclid's Elements *is...*

A. essentially a deductive system with definitions and basic assumptions.

B. essentially an inductive system with definitions and basic assumptions.

C. follows the model of Newton's *Principia*.

D. does not solve the problem of what really belongs in geometry and what doesn't.

Question 42

Question

In Euclid's Elements*, a Postulate is...*

A. the response to the simple injunction 'define your terms'.

B. a general statement whose truth is obvious or self-evident.

C. a basic supposition.

D. a consequence deduced logically from the definitions and axioms.

Question 43

Question

In Playfair's formulation, the fifth postulate of Euclidean geometry states that through any given point can be drawn at least one straight line parallel to a given line.

A. True.

B. False.

Question 44

Question

Immanuel Kant maintained that the proposition that the angles of all triangles add up to 180 degrees is...

A. analytic a priori.

B. analytic a posteriori.

C. synthetic a priori.

D. synthetic a posteriori.

Question 45

Question

What is a 'geodesic'?

A. The curve of shortest timelike distance between events.

B. The curve of greatest timelike distance between events.

C. The curve of shortest distance between two points.

D. The straight line between two points.

Question 46

Question

In a spherical geometry, how do triangles differ from their counterparts in Euclidean space?

A. Small triangles differ little, but the sum of angles of large triangles exceeds two right angles significantly.

B. Small triangles differ little, but the sum of angles of large triangles falls short of two right angles significantly.

C. Large triangles differ little, but the sum of angles of small triangles exceeds two right angles significantly.

D. Large triangles differ little, but the sum of angles of small triangles falls short of two right angles significantly.

Question 47

Question

Are geometries denying the parallel postulate consistent?

A. Yes, of course.

B. This is an open question; but these geometries are consistent if Euclidean geometry is.

C. This is an open question, regardless of whether Euclidean geometry is consistent.

D. No, not at all.

Question 48

Question

In a space of constant curvature, if parallel geodesics diverge, what can we tell about the curvature of the space?

A. Nothing.

B. That it is positive.

C. That it is zero.

D. That it is negative.

Question 49

Question

What is the curvature of the two-dimensional Euclidean sheet rolled up into a cylinder in 3-dimensional space as follows:

A. no extrinsic curvature, no intrinsic curvature

B. no extrinsic curvature, some intrinsic curvature

C. some extrinsic curvature, no intrinsic curvature

D. some extrinsic curvature, some intrinsic curvature

Question 50

Question

What does Einstein's general theory of relativity do without that Newton's theory of gravitation required?

A. curved spacetime

B. gravitational forces

C. free fall

D. equality of inertial and gravitational mass

Question 51

Question

In general relativity, the summed curvature of all spacetime sheets is proportional to the matter density (in every point).

A. True.

B. False.

Question 52

Question

If masses are distributed horizontally above the surface of a planet and then let to fall freely, what can we find out about the corresponding spacetime sheet?

A. That is has zero curvature.

B. That it is positively curved.

C. That it is negatively curved.

D. That there must be masses above the planet.

Question 53

Question

What is a relevant difference between Newton's theory of gravitation and general relativity?

A. In Newton's theory, but not in general relativity, there is no curvature in purely spatial space-space sheets.

B. In general relativity, but not in Newton's theory, the summed curvature of all sheets of spacetime, including space-space ones is proportional to matter density.

C. In Newton's theory, but not in general relativity, inertial mass equals gravitational mass.

D. All of the above.

Question 54

Question

How, if at all, is the space near the sun curved?

A. Negatively.

B. Positively.

C. Variably.

D. Only spacetime is curved, space isn't.

Question 55

Question

What is the effect of gravitation on the causal structure of spacetime?

A. It tips the light cones in the direction of the gravitational attraction.

B. It can widen the light cones.

C. Both (A) and (B).

D. It has no effect on the causal structure of spacetime.

Question 56

Question

Which one of the following is not a classic test of general relativity?

A. advancement of Mercury's perihelion
B. red shift in the light from distant sources
C. bending of light around massive objects
D. Michelsen-Morley experiment

Question 57

Question

What was Einstein's "happiest thought of his life"?

A. That a body in free fall doesn't have a weight.

B. That a uniform acceleration is equivalent to a homogeneous gravitational field.

C. That bodies must all fall alike, regardless of their horizontal speed.

D. That free fall transforms away gross effects of gravitation.

Question 58

Question

What is the following principle called?

Principle

The inertial effects inside a uniformly accelerated box in a space free of gravitation are equivalent to those of a homogeneous gravitational field.

A. Relativity Principle

B. Principle of the Relativity of Inertia

C. Mach's Principle

D. Equivalence Principle

Question 59

Question

Einstein inferred that light is bent in gravitational fields from the equivalence principle, among other things.

A. True.

B. False.

Question 60

Question

Which aspects of the propagation of light are affected by a gravitational field?

A. Neither its direction not its speed.

B. Its direction, but not its speed.

C. Its speed, but not its direction.

D. Both its direction and its speed.

Question 61

Question

Norton likens the possible universes (more precisely, spacetimes) as permitted in general relativity to the pages of the book. If these spacetimes are the pages of a book, what is the book itself?

A. The general theory of relativity (semantically understood).

B. Einstein's gravitational field equations.

C. The set of all admissible spacetime.

D. Relativistic cosmology itself.

Question 62

Question

Which spacetime can be taken to be a good approximation for the spacetime around the sun (neglecting that the sun rotates and has some electric charge)?

A. Einstein spacetime

B. Schwarzschild spacetime

C. de Sitter spacetime

D. Minkowski spacetime

Question 63

Question

Which spacetime describes a rotating universe with closed timelike curves?

A. Einstein spacetime
B. Gödel spacetime
C. de Sitter spacetime
D. Minkowski spacetime

Question 64

Question

Why did Einstein introduce the cosmological constant as an additional term into his field equations?

A. Because adding a repulsive force allowed him to create a static universe.

B. Because he recognized the possibility of negative masses.

C. Because he hoped to save Mach's principle in this way.

D. Because he wanted to permit vacuum solutions other than Minkowski spacetime.

Question 65

Question

If an observer would hurry towards a light source what would she find?

A. A shorter wavelength of the light.

B. A longer wavelength of the light.

C. A higher frequency of the light.

D. A lower frequency of the light.

Question 66

Question

Which of the following does not describe a Friedmann-Robertson-Walker spacetime?

A. An infinitely expanding, spatially flat universe.

B. An expanding and collapsing, spatially spherical universe.

C. An infinitely expanding, spatially hyperbolic universe.

D. An expanding and collapsing, spatially flat universe.

Question 67

Question

The value of the critical density roughly corresponds to how many hydrogen atoms per cubic meter of space?

A. 0.5
B. 5
C. 50
D. 500

Question 68

Question

Which of the following does not in general stop gravitational collapse?

A. The orbital motions of stars and planets.

B. Electric and magnetic repulsion among identically charged particles

C. Radiation emanating away the heat of stars.

D. Mechanical rigidity of rocks and incompressibility of the molten core of rocky planets.

Question 69

Question

Which of the following is not a difference between Newtonian and general-relativistic black holes?

A. Singular point of infinite matter density.

B. Singularity in spacetime curvature.

C. The causal isolation of regions of space and time.

D. The amount of energy released in the collapse that forms the black hole.

Question 70

Question

If a spaceship imprudently came too close to a black hole, then...

A. it would slow down and freeze just outside the event horizon.

B. an external observer would see it slow down and freeze just outside the event horizon.

C. an external observer would see it rapidly pass the event horizon without detectable bump.

D. an external observer would see everything occurring on it speed up.

Question 71

Question

In a 'conformal diagram' what do you find at the top (at the apex) of the figure?

A. past timelike infinity
B. future timelike infinity
C. past null infinity
D. future null infinity
E. spacelike infinity

Question 72

Question

In a 'conformal diagram' which geodesics are represented by straight lines?

A. timelike
B. lightlike
C. spacelike
D. none

Question 73

Question

Why can a traveller in a fully extended Schwarzschild spacetime not travel across an Einstein-Rosen bridge from region I to region III?

A. Because Einstein-Rosen bridges connect regions I and II, not I and III.

B. Because Einstein-Rosen bridges connect regions II and IV, not I and III.

C. Because it would require a speed faster than that of light.

D. Because Einstein-Rosen bridges are not stable.

Question 74

Question

What was a clue that the view that radiative matter such as light was a wave was too simple?

A. The thermal properties of heat radiation.

B. The thermal properties of gases.

C. The discreteness of atomic spectra.

D. The discreteness of particle energies.

Question 75

Question

Observations showed that light with high frequency could produce photoelectrons, even if the light was of very low intensity. How can this observation be explained?

A. If light is a wave, then dimmed light would still have enough energy to knock electrons out of the cathode.

B. If light energy is localized in quanta, then light quanta with low energy would still be able to knock out electrons.

C. If light is a wave, then decreasing the intensity doesn't change the energy of the wave.

D. If light energy is localized in quanta, then even individual light quanta can liberate photoelectrons so long as the frequency, and hence the energy, of the quanta is sufficiently high.

Question 76

Question

Which of the following was not a difficulty of Rutherford's atomic model?

A. That the positively charged nucleus didn't exert a sufficiently strong force to bind the electrons.

B. That the range of the emitted light would have to be continuous.

C. That the electrons would quickly clash into the nucleus.

D. That there was no limit the emission of light to just a few special frequencies.

Question 77

Question

What does Heisenberg's 'Uncertainty Principle' assert?

A. The indeterminacy in position plus the indeterminacy in momentum is greater than or equal to $h/2\pi$.

B. The indeterminacy in position plus the indeterminacy in momentum is less than or equal to $h/2\pi$.

C. The indeterminacy in position times the indeterminacy in momentum is greater than or equal to $h/2\pi$.

D. The indeterminacy in position times the indeterminacy in momentum is less than or equal to $h/2\pi$.

Question 78

Question

What is the consequence of applying Heisenberg's Uncertainty Principle to the hydrogen atom?

A. Its electron cannot exist in bound states in Bohr's model of the atom.

B. Because the atoms are so small (and hence the indeterminacy in the electron's position), their electrons will escape from the nucleus.

C. The indeterminacy in the electron's position is roughly the size of the atom.

D. Because of the electron's indeterminacy in angular momentum, its angular position must be completely indeterminate for it to remain on one of Bohr's stationary orbits.

Question 79

Question

Norton is avoiding talk of 'uncertainty' in favour of 'indeterminacy'. Why?

A. 'Uncertainty' is an epistemic term, but the magnitudes in question are truly indeterminate.

B. 'Indeterminacy' is an epistemic term, but the magnitudes in question are truly indeterminate.

C. 'Uncertainty' is an ontic term, but the magnitudes in question only concern our state of knowledge.

D. 'Indeterminacy' is an ontic term, but the magnitudes in question only concern our state of knowledge.

Question 80

Question

Which of the following is not a consequence of the linearity of Schrödinger's wave equation which governs the 'Schrödinger evolution'.

A. Schrödinger evolution is deterministic.

B. Schrödinger evolution does not typically lead to a unique value for position or momentum measurements.

C. Schrödinger evolution describes the 'collapse of the wave packet'.

D. Schrödinger evolution leaves 'superposition states' in superposition states.

Question 81

Question

A so-called ‘collapse of the wave packet’...

A. instantaneously spreads the wave packet over all of space.

B. instantaneously sharply converges the wave packet.

C. slowly spreads the wave packet over all of space.

D. slowly sharply converges the wave packet.