1. What does a rocket push against to accelerate?
   A. gravity
   B. residual atmosphere surrounding earth
   C. inertia of the ejected fuel
   D. itself
   E. it doesn't have to push against anything to accelerate

C

2. Armed with a spray paint can, stranded outside the shuttle, what do you do to ensure getting back?
   A. throw can toward shuttle
   B. throw can away from shuttle
   C. spray contents toward shuttle
   D. spray contents away from shuttle
   E. D, then B

E

3. Stranded on a sled on a frictionless frozen lake, which cargo would give you the greatest total boost?
   A. 25 lbs of BBs (plus a BB gun to shoot them)
   B. 25 pounds of chocolate chip cookies
   C. 25 pounds of bricks
   D. a 25 pound cinder-block
   E. these would all be equivalent

A

4. If earth were the same diameter, but more massive, what would acceleration due to gravity do (would it still be 10 m/s^2)?
   A. It would stay the same
   B. It would become weaker
   C. It would become stronger
   D. Gravity is independent of mass

C

5. Why are shuttle astronauts said to be "weightless" in space?
   A. Because they are far from earth, so gravity is too small to perceive
   B. Because they are falling with the shuttle, and have no *relative* acceleration
   C. The weightlessness is just a myth

B

6. Which of the following best describes geosynchronous satellites?
   A. They appear to be stationary, so aren't actually orbiting
   B. They actually *are* orbiting, but appear to be stationary because of earth's rotation
   C. They are far enough from earth that earth's gravity is effectively gone

B

7. If asked to design a space station with a radius of 10 meters, how fast would it have to spin (at the outer edge) to simulate earth gravity? (use v^2/r)
   A. 1 m/s
   B. 5 m/s
   C. 10 m/s
   D. 50 m/s
   E. 100 m/s

C

1. If there *was* an ether, and a flash was emitted from the center of a spaceship traveling through the ether, which of the following would be observed?
   A. The pulse would hit the back wall first
   B. The pulse would hit the front wall first
   C. The pulse would hit both walls at the same time

A

2. At 0.866*c*, $\gamma = 2.0$. Which of the following would *you* observe about a 1 meter clock traveling past at this speed? [stretch/contract along direc. of travel]
   A. The clock would appear to be 1 m, and tick at 1 s
   B. stretched to 2 m, and tick twice/sec
   C. contracted to 0.5 m, and tick at 2 sec intervals
   D. contracted to 0.5 m, and tick twice/sec
   E. stretched to 2 m, and tick at 2 sec intervals

C

3. In the previous case, if you're holding an identical clock (1 m across), what would the speedy traveler at $0.866c$ ($\gamma = 2$) note about your clock?
   A. Your clock would appear to be 1 m, and tick at 1 s
   B. stretched to 2 m, and tick twice/sec
   C. contracted to 0.5 m, and tick at 2 sec intervals
   D. contracted to 0.5 m, and tick twice/sec
   E. stretched to 2 m, and tick at 2 sec intervals

C

4. Using $E = mc^2$, what is the energy equivalent of 1 kg of mass?
   A. 1 J
   B. 300,000,000 J
   C. 3×10^8 J
   D. 9×10^{16} J
   E. 90,000,000,000,000,000 J

D,E

1. Earlier, we learned that 1 kg of mass is equivalent to 9×10^{16} J of energy ($E = mc^2$). If the U.S. annual energy usage is 10^{20} J, how many kilograms of mass-energy do we use per year? (c.f. 10^{12} kg oil)
   A. about 1 kg
   B. about 10 kg
   C. about 100 kg
   D. about 1,000 kg
   E. about 10,000 kg

D

2. Why is centrifugal "force" necessarily proportional to mass? (recall $F = ma$)
   A. Because more massive objects have a greater centrifugal acceleration
   B. Because the reference frame accelerates the same toward all objects
   C. Because the force is the same for all objects
   D. Because it's a fictitious force, so it can do whatever it wants

B

3. Recap: Why would Einstein say that all objects fall at the same acceleration in earth's gravitational field?
   A. Because it's the earth reference frame that is accelerating relative to the objects
   B. Because gravitational force is proportional to mass, and $F = ma$, so $a = F/m$ = constant
   C. Because both objects move at constant velocity relative to the earth's surface

A

7. What should the reaction be if any future experiment shows a deficiency in general relativity?
   A. Ignore it: it's just one of many experiments
   B. Perform an independent analysis of the data
   C. Perform a parallel, independent experiment
   D. Throw GR out: it's clearly wrong
   E. Stop teaching GR in schools until it's resolved

B,C

1. Electrical forces are 10^{40} times stronger than gravitational forces. Why then don't you feel electrical forces routinely?
   A. Because we have no electrical charges in us
   B. Because our skin shields us from electrical forces
   C. Because we have just as many positive charges as negative
   D. Because gravity involves the entire earth, but earth has no charges

C

2. Why do we have "electronics" and not "protonics"?
   A. It's an arbitrary choice: any charge will do
   B. We just choose to use electrons for our devices
   C. Electrons are easier to move because they're lighter
   D. Electrons are more easily removed from atoms
   E. Protons are too massive and cause damage when they bump into things

D

3. If I stick two pieces of scotch tape on a table (separately), and peel them off, will they attract or repel?
   A. neither
   B. attract
   C. repel
   D. both, since it's Sun God day

C

4. If I pull one piece of scotch tape off of another, do they attract or repel?
   A. neither
   B. attract
   C. repel
   D. both, since it's still Sun God

B

5. If a spark is 1 mm long, and air breaks down at 3 million volts per meter, how many volts did it take to activate the mm spark?
   A. 30 V
   B. 300 V
   C. 3,000 V
   D. 30,000 V
   E. 300,000 V

C

1. How far would I have to separate two +2 charges (He nuclei) to have the same force as two +1 charges (H nuclei, or protons)?
   A. one fourth the distance between protons
   B. one half the distance as the protons
   C. same distance as the protons
   D. twice the distance of the protons
   E. four times the distance of the protons

D

2. How much stronger would two carbon nuclei (6 protons each) repel each other than two hydrogen nuclei (single protons) at half the distance?
   A. 1.5 times stronger
   B. 3 times stronger
   C. 6 times stronger
   D. 9 times stronger
   E. 36 times stronger

D

3. If we could somehow deposit a lot of electrons on the surface of the floor, which way would the electric field point, and what would be the electric force direction on a negatively charged ball thrown across the room?
   A. electric field points up; force on ball is down
   B. electric field points up; force on ball is up
   C. electric field points down; force on ball is down
   D. electric field points down; force on ball is up

D

4. If I wanted to deflect a beam of electrons downward when passing between two horizontal plates, which is the correct arrangement?
   A. top plate positive, electric field points up
   B. top plate negative, electric field points up
   C. top plate positive, electric field points down
   D. top plate negative, electric field points down

B

1. Which of the following actions is likely to produce an electromagnetic wave?
   A. waving a charged stick/rod through the air
   B. making a spark between my finger and a doorknob
   C. lightning strike
   D. getting something really hot, wiggling its electrons
   E. turning on/off an electrical circuit

all

2. Using $c = 3\times10^8$ m/s, what is the wavelength of a typical FM station (100 MHz = 10^8 Hz)?
   A. 3 cm
   B. 30 cm
   C. 3 m
   D. 30 m
   E. 300 m

C

3. Why are car antennas oriented vertically?
   A. For aerodynamic reasons
   B. The choice is arbitrary: a matter of convenience
   C. The magnetic field from radio transmitters oscillates vertically
   D. The electric field from radio transmitters oscillates vertically
   E. The electric field from radio trans. oscillates horizontally

D

4. Why would you guess cell phone antennas are short?
   A. Because they wouldn't fit in your pocket otherwise
   B. The length of the antenna is not important to signal reception
   C. The wavelength of cell phones must be shorter than typical FM radio
   D. The frequency must be appreciably higher than 100 MHz

D

1. If I wiggle an electron, what happens?
   A. nothing interesting
   B. the electric field instantly follows at all distances
   C. a magnetic field is produced
   D. electromagnetic radiation is emitted
   E. all of the above

D (also C)

2. Which has more energy: a photon of red light with λ = 700 nm, or a photon of blue light with λ = 400 nm (careful!)?
   A. The red photon has more energy
   B. The blue photon has more energy
   C. All photons have identical energy
   D. It is not appropriate to speak of the energy of a single photon
   E. It depends on the source that emitted the photon

B

3. What is a ballpark momentum ($p = mv$) you might expect for a macroscopic object moving through this room?
   A. 10^{-20} kg·m/s
   B. 10^{-10} kg·m/s
   C. 10^{0} kg·m/s
   D. 10^{10} kg·m/s
   E. Any of these are valid

C

4. What, then, is a typical de Broglie wavelength for a macroscopic object? (λ = h/p), and h = 6.63×10^{-34} J·s)
   A. about 10^{-33} m
   B. about 10^{-23} m
   C. about 10^{-13} m
   D. roughly one meter
   E. about 10^{13} m

A

1. Why, in the quantum view, does the hydrogen atom *not* decay in a matter of nanoseconds?
   A. the problem is still there in the quantum view
   B. the electron distribution is static: no EM waves
   C. EM waves are only allowed to come out at discrete energies
   D. time has slowed to a near stop due to speeds near *c*
   E. the mutual repulsion of electrons keeps them from spiraling in

B, C is true

2. R + G + B = white; R + G = Yellow, R + B = Magenta, G + B = Cyan. A shirt that absorbs only blue light will appear:
   A. blue
   B. yellow
   C. magenta
   D. cyan
   E. none of the above

B

3. R + G + B = white; R + G = Yellow, R + B = Magenta, G + B = Cyan. A shirt that absorbs red and green light will appear:
   A. blue
   B. yellow
   C. magenta
   D. cyan
   E. none of the above

A

4. R + G + B = white; R + G = Yellow, R + B = Magenta, G + B = Cyan. If I mix cyan paint with magenta paint, the resulting mix will appear:
   A. blue
   B. yellow
   C. magenta
   D. cyan
   E. none of the above

A

5. Why do you get black or brown when mixing lots of paints together?
   A. Black/Brown is the universal primary color
   B. It's a chemical reaction that makes it dark
   C. Collectively, all wavelengths/colors are absorbed
   D. Impurities get into the mix and make it dark

C

1. Why does a darkly-colored shirt get hotter than a white shirt in the sun?
   A. the dark shirt traps heat, like greenhouse gases
   B. colors absorb light; the darker, the more light/energy/heat is being absorbed
   C. this is an accident of nature, and does not relate to physics
   D. dark shirts are no hotter than white shirts in the sun
   E. it's not directly due to color, but more about the material

B

2. Why do you think wave crests lining up create constructive interference, whereas trough-crest superposition results in cancellation?
   A. no idea
   B. crests "fill in" troughs and balance to zero
   C. the electric fields are in different directions for crests and troughs, so can add or cancel depending on alignment
   D. cancellation is not possible with light: it's made of photons after all, not waves

C

3. Why do you think fluorescence robs from the "blue" and gives to the "red," rather than the other way around?
   A. it's arbitrary: could have gone either way
   B. this isn't universally true
   C. doing otherwise would require extra energy to come from somewhere to generate a blue photon
   D. blue photons have less energy than red photons

C

1. Why is the sky blue?
   A. air molecules more readily scatter blue photons
   B. air molecules are intrinsically blue
   C. sunlight is intrinsically blue and lights up the air
   D. It's the amount of oxygen that makes it blue
   E. still no idea

A

2. If the physics of scattering worked the other way so that the sky was red, what color would sunsets be?
   A. still red
   B. more yellow-ish
   C. sort-of green
   D. blue-ish
   E. if scattering worked the other way, we wouldn't be around to enjoy sunsets

D, E probably true!

3. Which direction should you look to see a rainbow in the evening?
   A. north
   B. south
   C. east
   D. west

C

4. Why don't you see rainbows during mid-day
   A. rain never happens mid-day
   B. rain and sun together don't happen mid-day
   C. the sky is too bright, so you just don't notice
   D. the rainbow is opposite the sun, and the sun is too high
   E. they happen at all times of the day with equal likelihood

D

1. If Uranium is element number 92 on the periodic table, how many neutrons and protons does ^{235}U contain?
   A. 46 protons, 46 neutrons
   B. 92 protons, 92 neutrons
   C. 92 protons, 143 neutrons
   D. 143 protons, 92 neutrons
   E. 235 protons plus neutrons, but always switching about

C

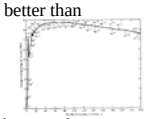
2. Let's say I put 1000 kg of Uranium into a nuclear reactor core; let it do its thing for a year, and pulled it out to find its mass is 1 kg less than it was, but no nucleons have escaped. How much energy was produced?
   A. Say what?
   B. $E = mc^2$, so $(1\text{ kg})\times(3\times10^8\text{ m/s}) = 3\times10^6\text{ J} = 300\text{ MJ}$
   C. $(1\text{ kg})\times(9\times10^{16}\text{ m}^2/\text{s}^2) = 9\times10^{16}\text{ J}$
   D. $(999\text{ kg})\times c^2 = 9\times10^{19}\text{ J}$

ↄ

3. If my reactor "burns" through 9×10^{16} J in a year (3×10^7 seconds), how much power does it produce?
   A. $3\times10^9\text{ W} = 3\text{ GW}$
   B. $9\times10^{16}\text{ W} = 90$ Quadrillion Watts
   C. $27\times10^{23}\text{ W}$
   D. don't know how to do this problem

∀

4. Interpreting the graph, why is fusion better than fission?



   A. it's cleaner environmentally
   B. the supply is virtually unlimited
   C. nine out of ten stars recommend it
   D. more energy gain available on left side than on right
   E. fission is actually a loss of energy

ɑ

4. Which is anthropic reasoning for why we find life on Earth?
   A. because Earth was put where it should be to support life
   B. because life adapted itself to Earth's conditions
   C. because *we* must find ourselves on a life-bearing planet
   D. because Earth is likely the only life-bearing planet in the solar system
   E. because Earth is likely the only life-bearing P in the U'verse

ↄ