P102 University of Rochester NAME Solnkey - SLM
S. Manly Spring 2011

Final Exam (May 3, 2011)

Please read the problems carefully and answer them in the space provided. Write on the back of the page, if necessary.

Problem 1 (3 pts, no need to show work, circle best answer):

Is it possible to prove, for certain, that a scientific theory is true?

a) Yes, by means of a single confirmed experiment that verifies the theory.
b) Yes, by carying out a sufficient number of experimental observations.
c) Yes, dy decuding it logically from other scientific theories that are known to be true. inductive
d) No, because it is always possible tthat a future experiment will disagree wth the theory.
e) No, because the experimental error, or uncertainty, that is always present in any experimental result.

Problem 2 (4 pts, no need to show work, circle best answer):

You hold a 5 newton rock in motionless in your hand while standing on Earth's surface. Regarding the forces on this rock,

4 - a) the net force on the rock is zero. — otherwise it would accelerate
b) the net force on the rock is 5 newtons, directed upward.
c) the net force on the rock is 5 newtons, directed downward.
2 - d) there are no forces of any kind acting on the rock, because it is not moving.
e) there are none, because forces were not born to rock

Problem 3 (4 pts, no need to show work, circle best answer):

You are in distant space where there is no gravity. You hold two cubes of metal that look and feel identical when touched, but you have been informed that one of the cubes is made of lead and one is made of lightweight aluminum. Can you determine which one is lead without doing a chemical analysis?

a) Yes, you can do this by releasing them; the lead ball will fall fastest.
b) Yes, you can do this by releasing them; the aluminum ball will fall fastest.
c) Yes, you can do this by releasing them and tapping each lightly with your finger; the one that accelerates the most is made of lead.
d) Yes, you can do this by releasing them and tapping each lightly with your finger; the one that accelerates the most is made of aluminum.
e) No, it is not possible to distinguish the two cubes without doing a chemical analysis.

Scores	
1.	___/3
2.	___/4
3.	___/4
4.	___/5
5.	___/5
6.	___/6
7.	___/4
8.	___/3
9.	___/3
10.	___/3
11.	___/4
12.	___/3
13.	___/3
14.	___/3
15.	___/3
16.	___/3
17.	___/4
18.	___/4
19.	___/5
20.	___/5
21.	___/8
22.	___/5
23.	___/10
Total	___/100

Problem 4 (5 pts, defend answer):

You stand on Earth and have in your grasp the two cubes from the problem above. Suppose you drop them at the same instant from the same height. Which one hits the ground first, or do they hit at the same time? Briefly defend your answer.

$F = ma = mg$ The acceleration is independent of the mass. So they will hit the ground at the same time.

Problem 5 (5 pts, defend answer):

If you take a trip to the moon, would you expect your mass or your weight to change? Which – either or both – would change? Why?

Mass does not change. Weight = force with which you are attracted by gravity to Earth/moon. That changes since $F_{grav} = \frac{GMm}{r^2}$ for the moon this is 1/6 that of Earth

Problem 6 (6 pts, show reasoning):

Consider two balls moving left to right in one dimension along a ruler with marks every centimeter (cm) – not shown exactly to scale in the drawing. The position of each ball at the start of each of five consecutive seconds is shown on the drawing below.

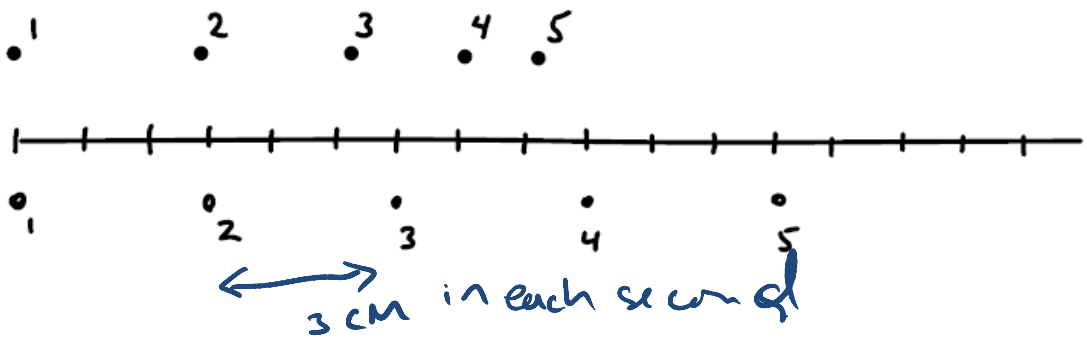
Which, if either, ball is accelerating? Explain

The top ball is accelerating

(The acceleration is negative, but it is accelerating nonetheless.)

What is the speed of the bottom ball in centimeters/second?

3 cm/second



Problem 7 (4 pts, no need to show work, circle best answer):

Suppose you release a single proton from rest as some point X in space where there is a constant electric field. Then a bit later you release a single electron from rest at the same point X. How would the motions of the proton and the electron compare, just after their release from rest?

a) They would move in the same direction, and the proton would move fastest.
b) They would move in the same direction, and the electron would move fastest.
c) They would move in opposite directions, and the proton would move fastest.
d) They would move in opposite directions, and the electron would move fastest.
e) They would move in opposite directions, and at the same speed.
f) They would move in the same directions, and at the same speed.

opposite directions because charges are opposite. e moves fastest because F is same magnitude and Mass is smaller so a is bigger

Problem 8 (3 pts, no need to show work, circle best answer):

For light waves, different frequencies mean different

a) brightness.
b) color.
c) amplitudes.
d) speeds.
e) None of the above.

Problem 9 (3 pts, no need to show work, circle best answer):

Anne-Marie "Snooky" Algiers and Joel "C-note" Seligman fight it out after an interstellar drug deal gone back. Snooky Algiers flies away from C-note Seligman in her smuggling spaceship at speed of 0.9c. If C-note shoots a laser beam at Snooky and just misses her, how fast does Snooky perceive the light in the laser beam to be moving?

a) c.
b) 0.9c.
c) 0.1c.
d) 1.1c.
e) (gamma)c

Speed of light perceived to be c No matter what your point of view.

Problem 10 (3 pts, no need to show work, circle best answer):

Nuclear fusion is a process in which

a) a small particle is spontaneously emitted from a nucleus.
b) atoms combing into molecules.
c) a heavy nucleus is split into two or more lighter nuclei.
d) two or more light nuclei are combined into a single heavier nucleus.
e) None of the above.

Problem 11 (4 pts, show your reasoning): 5×8 = 40

One of the radioactive isotopes released in the Fukushima nuclear accident was Iodine-131. The half-life of Iodine-131 is 8 days. How long will it take after its initial release (assuming no additional releases) for the amount of Iodine-131 in the environment to drop to 1/32 (about 3%) of its initial value? Show your reasoning.

halflives 1 2 3 4 5
amt remaining 1/2 1/4 1/8 1/16 1/32

a) 8 days.
b) 24 days.
c) 40 days.
d) 56 days.
e) It is impossible to determine this according to the laws of quantum mechanics.

Problem 12 (3 pts, no need to show work, circle best answer):

Supersymmetry is a fundamental symmetry in nature between

a) fermions and bosons.
b) leptons and quarks.
c) mesons and baryons.
d) dark matter and normal matter.
e) matter and antimatter.

Problem 13 (3 pts, no need to show work, circle best answer):

The cosmic microwave background

a) originates from the naturally radioactive substances decaying all around us over time.
b) originates from the stage in the big bang when neutral atoms were formed.
c) originates from the countless number of distant galaxies in the universe.
d) originates from the early stage in the big bang when free quarks and gluons formed neutrons and protons.
e) originates from the nuclear fusion processes that happen during stellar supernovas in distant regions of our universe.

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Problem 14 (3 pts, no need to show work, circle best answer):

Protons are made of

a) leptons.
b) quarks.
c) hadrons.
d) photons and Z particles.
e) nothing since they are fundamental particles in the standard model.

Problem 15 (3 pts, no need to show work, circle best answer):

Neutrinos are hard to detect because

a) they move so fast.
b) they experience only the weak nuclear and gravitational forces.
c) they have such a tiny mass.
d) they experience only the gravitational force.
e) None of the above.

Problem 16 (3 pts, no need to show work, circle best answer):

According to current scientific theories, most of the hydrogen atoms in your body likely originated from

a) an early stage of the big bang.
b) fusion processes taking place in the cores of stars.
c) fission processes taking place in the cores of stars.
d) fusion processes taking place during supernovas.
e) fission processes taking place during supernovas.
f) inverse beta decay when neutrinos scatter on nuclei.

Problem 17 (4 pts, no need to show work, circle best answer):

Briefly describe one bit of evidence that light can be described as a wave.

2 of 7

interference - The way that light wave add together constructively and destructively

Refraction - The way light bends at the interface between two media

Diffraction - The way light spreads out after passing through a tiny slit or opening

Problem 18 (4 pts):

Briefly describe one bit of evidence that light can be described as a particle.

- blackbody radiation spectrum - The glow from objects can only be understood by assuming light has particle characteristics
- Photoelectric effect - ejection of electrons from heated
- discrete atomic spectra

Problem 19 (5 pts):

How does a beam of gamma rays differ from a beam of light from an ordinary flashlight?

They are fundamentally the same phenomenon. Gamma rays have a much higher frequency than visible light or Gamma ray photons are more energetic than visible light photons.

Problem 20 (5 pts):

Why is dark matter called "dark" matter?

It does not interact with light and therefore cannot be seen optically

Problem 21 (8 pts):

Briefly describe two problems with the big bang theory that are avoided by the inclusion of cosmological inflation in the theory.

Singularity - Extrapolating back big bang leads to ∞ density Singularity where physics as we know it breaks down

Horizon problem - distant parts of our universe have the same temperature to 1 part in 10^5 and yet have always been causally disconnected

Flatness problem - The space of our universe is measured to be flat - a special case.

large scale structure problem - The big bang by itself has no mechanism for generating the energy and density fluctuations that are necessary to get large scale structure (galaxies, galactic clusters, stars) in our universe.

Problem 22 (5 pts):

Briefly describe one reason many physicists are very excited about string theory as a potential foundation for a "theory of everything".

- Because the strings are extended objects – problems plaguing theories at small distances are less.
- String theories naturally have "gravitons" ... are thought to be suitable for quantum gravity
- String theories naturally include supersymmetry

Problem 23 (10 pts):

In short paragraph form, briefly describe below two distinct multiple universe concepts.

Must choose + briefly describe 2 of the 11 Multiverse concepts in Visions of the Multiverse Appendix A ... on could chose 2 of Max Tegmark's 4 multiverse concepts/categories (given in Appendix B in Visions of the Multiverse.

Some potentially useful formulas

$F = \frac{G m_1 m_2}{r^2}$ (m_1 and m_2 in kg, r in meters) $\rightarrow G = 6.7 \times 10^{-11}$ (Force in Newtons)

$F = \frac{k q_1 q_2}{r^2}$ (q_1, q_2 in Coulombs, r in meters) $\rightarrow k = 9 \times 10^9$

$F = ma$

(distance) = (speed)(time)

$v = \frac{\Delta x}{\Delta t}$

$a = \frac{\Delta v}{\Delta t}$

work = force x distance

Momentum = $p = mv$

$\Delta x' = \gamma \Delta x$, length longest in proper frame

$\Delta t' = \gamma \Delta t$, time shortest in proper frame

$\gamma = \frac{1}{\sqrt{1 - \left(\frac{v}{c}\right)^2}}$

1 Joule = 1.6×10^{-19} eV

speed of sound = 330 m/s

$c = 3 \times 10^8$ m/s

$v = \lambda \nu$

$\nu = \frac{1}{T}$ (T = period)

gravitational force at Earth's surface

$F = mg$ where

$g = \frac{G M_E}{R_E^2} = 9.8$ m/s^2

$\Delta x \Delta p \gtrsim h$
or
$\Delta x \Delta v \gtrsim h/m$
$\Delta E \Delta t \gtrsim h$

$h = 6.63 \times 10^{-34}$ J s