Physics 100   Final Exam (12/21/01)
****Print your name legibly at the top of the page ******

$\text{speed} = \text{v} = \frac{\text{distance}}{\text{time}}$; $\text{time} = \frac{\text{distance}}{\text{v}}$; $\text{distance} = \text{v} \times \text{time}$; $\text{momentum} = \text{p} = \text{mv}$

$\text{wave speed} = \text{freq.} \times \text{wavelength}$; $\text{wavelength} = \frac{\text{speed}}{\text{freq.}}$; $\text{freq.} = \frac{\text{speed}}{\text{wavelength}}$

$\text{Work} = F \cdot d$; $\text{K.E.} = \frac{1}{2}mv^2$; $\text{grav. P.E.} = mgH$; $\text{Power} = \frac{\text{Energy}}{\text{time}}$

$F_{\text{grav}} = G\frac{m_1 m_2}{d^2}$, $G = 6.7 \times 10^{-11}\frac{Nm^2}{kg^2}$; $g_{\text{Earth}} = G\frac{M_{\text{Earth}}}{R_{\text{Earth}}^2} = 10\frac{m}{s^2}$

$F_{\text{elec}} = k\frac{q_1 q_2}{d^2}$, $k = 9 \times 10^9 \frac{Nm^2}{coul^2}$; $F_{\text{mag}} = \kappa\frac{I_1 I_2 \ell}{d}$, $\kappa = 2 \times 10^{-7}\frac{N}{A^2}$

$\text{current} = \frac{\text{coulombs}}{\text{elapsed time}} = \frac{\text{voltage}}{\text{resistance}}$; $\text{power} = \text{current} \times \text{voltage}$

$E = mc^2$ $c = \text{speed of light in vacuum} = 3 \times 10^8 m/s$

Uncertainty Relation: $\Delta x \Delta p = \Delta x \cdot m \Delta v = h = 6.6 \times 10^{-34} Js$

Photon energy: $E_{phot} = h \times f$;   de Broglie wavelength: $\lambda = \frac{h}{p} = \frac{h}{mv}$

$E_{quant} = h \cdot f$.; $h = \text{Planck's constant} = 6.6 \times 10^{-34} Js$

Answer all Multiple Choice Questions on the Answer Sheet*

"ONE HUNDRED TRILLION NEUTRINOS ARE PASSING THROUGH OUR BODIES EVERY SECOND, AND WE'RE WORRIED ABOUT THE PHYSICS 100 FINAL"

I

1. In a key play at the end of the first half, a 90 kg BYU quarterback dives toward the goal line at a speed of 3 m/s and is hit abnd grabbed in midair by a 120 kg UH linebacker diving in the opposite direction with a speed of 2.5 m/s. What happens?

   a) The quarterback knocks the linebacker backwards and scores a touchdown.

   b) The quarterback gets knocked backwards and BYU suffers an ignominious defeat.

   c) They both come to a dead stop and fall unto the goal line.

   d) Not enough information to tell.

2. A diver does a flip as shown. The direction of his angular momentum vector is:

   a) upward.

   b) downward.

   c) out of the page.

   d) into the page.

3. When Isaac Newton wrote down his laws of motion, he implicitly assumed that they were the same for all places in the Universe. What conservation law does this imply?

   a) Conservation of momentum.

   b) Conservation of angular momentum.

   c) Conservation of energy.

   d) Conservation of electric charge.

4. The fact that the pattern of absorption lines in the Sun's spectrum match the spectrum of emission lines for Hydrogen gas means:

   a) Nothing. This is just a coincidence.

   b) There is some hydrogen in the Sun's atmosphere.

   c) The Sun is getting hotter.

   d) The Sun is getting cooler.

5. How do astronomers tell the temperature at the surface of a star?

   a) From the neutrinos coming from it.

   b) From the star's brightness.

   c) From the characteristic spectral lines in the star's color spectrum.

   d) From the peak position of the star's blackbody radiation spectrum.

6. What process is responsible for producing the Sun's energy?

    a) Nuclear fusion of hydrogen nuclei into helium nuclei

    b) Nuclear fission of Uranium in the Sun's core.

    c) Radioactive beta decay.

    d) Radioactive alpha decay.

7. What force keeps the Earth in orbit around the Sun?

    a) Strong nuclear force.

    b) Electric force.

    c) Weak force.

    d) Gravity.

8. What force holds neutrons and protons together inside the atomic nucleus?

    a) Strong nuclear force.

    b) Electric force.

    c) Weak force.

    d) Gravity.

9. On an elementary particle level, which of the following forces is the weakest?

    a) Strong nuclear force.

    b) Electric force.

    c) Magnetic force.

    d) Gravity.

10. A young girl on a playground swing set swings back and forth with a frequency of 0.3 Hz. What is the quantum of her energy?

    a) 6.6×10^{-34} J.

    b) 2.0×10^{-34} J.

    c) 22×10^{-34} J.

    d) 30 J.

11. Why did quantum effects go unnoticed prior to the twentieth century?

    a) They *were* noticed, but went under a different name.

    b) Pre-twentieth century scientists were not very smart.

    c) Since Planck's constant is very small, quantum effects are not apparent in normal human activities.

    d) Quantum effects only became apparent when humans started travelling in outer space.

3

12. Suppose you are on a space ship, traveling away from Earth and the influence of Earth's (or any other object's) gravity. What statement about your *weight* and *mass* is correct?

a) Both your mass and your weight stay the same.

b) Both your mass and your weight decrease.

c) Your mass stays the same and your weight decreases.

d) Your weight stays the same and your mass decreases.

13. Astronauts on the Space Shuttle claim to feel weightless. This is because

a) they are above the Earth's atmosphere where the effects of the Earth's gravity are negligible.

b) they are confusing weightlessness with motion-induced nausea.

c) they are in free-fall and their body does not have to support their weight.

d) they are moving very fast, in which case the force of gravity goes to zero.

14. Which of the following statements is false?

a) $\vec{E}$-fields are produced by electric charges.

b) Changing $\vec{B}$-fields produce $\vec{E}$-fields.

c) Changing $\vec{E}$-fields produce $\vec{B}$-fields.

d) $\vec{B}$-field lines start on + charges and end on − charges.

15. Suppose that an astronaut, whose mass is 60 kg, is standing on the surface of Mars. (Mars has a mass $M_{Mars} = 6.4 \times 10^{23}$ kg and a radius of $R_{Mars} = 3.4 \times 10^6$ m.) What acceleration due to gravity does she experience?

a) 9.8 m/s^2

b) 0

c) 3.7 m/s^2

d) 1.7 m/s^2

16. Using all the physics he learned in physics 100, a man builds a 100 m long rocket ship and blasts off in it for outer space with a cruising speed of 0.99c, (At v=0.99c, $\gamma = 7.09$.) His twin sister remains on earth, watching his trip through an elaborate telescope. How long does the rocket appear to the sister on Earth.

a) 99 *m*.

b) 43.7 *m*.

c) 709 *m*.

d) 14.1 *m*.

17. Suppose the guy in the previous problem traveled to α-centauri, which is 4.3 cyr (light years) away. (At v=0.99c, $\gamma = 7.09$.) According to his sister on Earth, how many years does it take for him to get there?

    a) 0.60 years

    b) 4.34 years.

    c) 3.88 years.

    d) 9.85 years.

18. After the guy in the previous problems gets back from α-centauri,

    a) he is now much older than his sister.

    b) he and his sister are still the same age.

    c) he is now much younger than his sister.
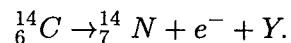
    d) he is younger than he was when he left.

19. Some scientists have proposed the following nuclear reaction as a new source of nuclear energy:

    $$X +_5^{11} B \rightarrow_2^4 He +_2^4 He +_2^4 He.$$
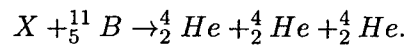
    What is X?

    a) a neutron ($_0^1 n$).

    b) a neutrino.

    c) an α particle ($_2^4 \alpha$).

    d) a proton ($_1^1 p$) .

20. A $_6^{14} C$ nucleus decays via the process:
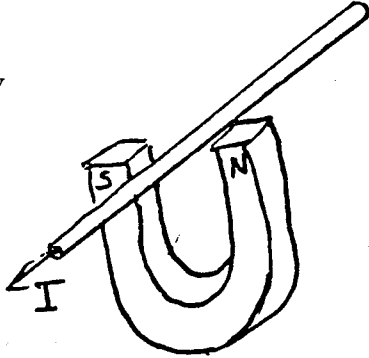
    $$_6^{14} C \rightarrow_7^{14} N + e^- + Y.$$

    What is Y?

    a) a neutron ($_0^1 n$).

    b) a neutrino.

    c) an α particle ($_2^4 \alpha$).

    d) a proton ($_1^1 p$) .

21. Isotopes are different atomic nuclei with

    a) the same number of neutrons but different numbers of protons.

    b) the same number of neutrons and protons.

    c) the same number of protons but different numbers of neutrons.

    d) different numbers of protons and different numbers of neutrons.

5

22. Electrons emerging from the 2-mile long Stanford accelerator have a speed so close to the speed of light ($v = 0.99999999995c$) that their relativistic γ-factor is $\gamma = 1 \times 10^5$. What is the mass of one of these moving electrons? (The mass of an electron at rest is 9×10^{-31} kg.)

   a) 9×10^{-31} kg.

   b) 9×10^{-26} kg.

   c) 9×10^{-36} kg.

   d) 1×10^{-5} kg.

23. What is the deBroglie wavelength for the electrons in the previous problem ($v \simeq c$, $\gamma = 1 \times 10^5$)?

   a) 2.4×10^{-12} m.

   b) 7.3×10^{-8} m.

   c) 2.4×10^{-17} m.

   d) 7.3×10^{-4} m.

24. What quarks make up a proton?

   a) $u\ u\ d$.

   b) $d\ d\ u$.

   c) $u\ \bar{d}$.

   d) None of the above, there are no quarks in a proton.

25. What quarks make up a π^+ meson?

   a) $u\ u\ d$.

   b) $d\ d\ u$.

   c) $u\ \bar{d}$.

   d) None of the above, there are no quarks in a π^+ meson.

26. What quarks make up an electron?

   a) $u\ u\ d$.

   b) $d\ d\ u$.

   c) $u\ \bar{d}$.

   d) None of the above, there are no quarks in an electron.

27. The Sun has a total power output of 3.9×10^{26} Watts (Joules/sec). How much of the Sun's mass is converted into energy each year?

   a) 3.5×10^4 kg.

   b) 1.4×10^{17} kg.

   c) 0.35 kg.

   d) 4.3×10^9 kg.

28. Why do Boron ($Z = 5$) and Aluminum ($Z = 13$) have similar chemical properties?

   a) They both have 3 electrons in their outermost shell.

   b) The both are near the top of Mendeleev's Periodic Table.

   c) They are both different isotopes of the same chemical element.

   d) They do not have similar properties; they are, in fact, quite different.

29. What happens when matter and antimatter meet?

   a) Nuclear beta decay.

   b) Nuclear fission.

   c) Nuclear fusion.

   d) They annihilate into photons.

30. The frequency of the musical note "middle C" is 264 Hz. What is its wavelength in air? (The speed of sound in air is 340 m/s.)

   a) 1.29 m.

   b) 0.78 m.

   c) 2.64 m.

   d) 3.40 m.

31. Microwaves in a microwave oven have a frequency 1.5×10^{10} Hz. What is the photon energy for these microwaves?

   a) 9.9×10^{44} J.

   b) 9.9×10^{-24} J.

   c) 4.4×10^{-44} J.

   d) 1.5×10^{-26} J.

32. An electric-current-carrying wire passes nearby a magnet as shown in the figure. What is the direction of the magnetic force on the wire?

   a) Up.
   b) Down.
   c) Right.
   d) Left.

33. How many different types of quarks have been discovered?

   a) Three.
   b) Four.
   c) Five.
   d) Six.

34. Doctors use ultrasound, sound waves with frequencies of a few million hertz, to follow the development of fetuses in their mother's womb. What is the minimum size of fetal features that doctors would be able to distinguish using ultrasound waves with a frequency $f = 3 \times 10^6$ Hz? (The speed of sound in human tissue is 1500 m/s.)

   a) About 5 cm.

   b) About 5 mm.

   c) About 0.5 mm.

   d) About 0.05 mm.

35. Two 1-m long parallel wires are separated by a distance of 0.01m and each carry a current of 20A in the *same* direction. The force between the wires is
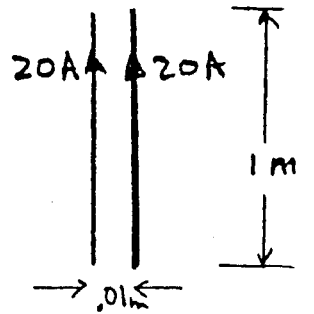
   a) 2×10^{-7} N.

   b) 4×10^{-5} N.

   c) 8×10^{-5} N.

   d) 8×10^{-3} N.

36. Two +20 Coulomb electric charges are separated by a distance of 0.01m. The force between them is

   a) 3.6×10^{14} N.

   b) 3.6×10^{16} N.

   c) 1.8×10^{12} N.

   d) 9.0×10^{12} N.

37. According to Maxwell's theory, the speed of light is related to which of the following?

   a) The ratio of the strengths of the electric and strong nuclear forces.

   b) The ratio of the strengths of the magnetic and gravitational forces.

   c) The ratio of the strengths of the electric and magnetic forces.

   d) The ratio of alpha-decay to beta-decay.

38. When Dirac combined the theories of Relativity and Quantum Mechanics, he found that some solutions for electron waves had negative frequencies, which seemed to indicate *electrons going backwards in time*. What, in fact, do these solutions represent?

   a) Antielectrons.

   b) Protons.

   c) Neutons.

   d) Neutrinos.

39. Astronomers studying the spectrum of light from a distant galaxy notice an arrangement of color lines with a pattern similar to that for hydrogen, but shifted toward the red side of the color spectrum. From this they can infer that the galaxy is

   a) cooling off.

   b) heating up.

   c) moving away from us.

   d) moving toward us.

40. What does Pauli's Exclusion Principle exclude?

   a) More than 25% of Physics 100 students getting A's.

   b) More than one electron in a quantum energy state.

   c) Electric and magnetic fields at the same point in space.

   d) Simultaneous measurements of position and momentum with arbitrarily good precision.

EXTRA CREDIT

E1 DeBroglie said that electrons propagate through space like waves. On the figure at the right, sketch what the electron waves look like for the $n = 2$ and $n = 4$ quantum states in the hydrogen atom.
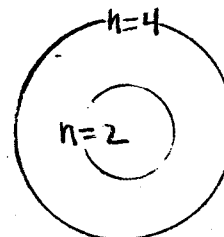
E2 Maxwell predicted that light was a wave of oscillating $\vec{E}$- and $\vec{B}$-fields.
Make a sketch of what one might look like, indicating the directions of the $\vec{E}$- and $\vec{B}$-fields and the direction of propagation.

E3 Sketch the pattern of detected electrons for the case where they are directed at a screen through a single slit as shown. The width of the slit is about the same as the electrons DeBroglie wavelength.
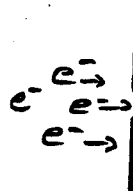
E4 Sketch the pattern for the same electrons where they are directed at the screen through two single slits as shown. Again, the width of the slit is about the same as the electrons DeBroglie wavelength.
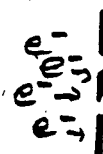
E5 Match the person in column A with the subject or equation in column B that he or she is most closely associated with.

A) Person	(answer)	B) Subject
a) Emmy Noether	_____	1. Wave equation for Quantum Mechanics
b) Isaac Newton	_____	2. Wavelengths of particles
c) Nils Bohr	_____	3. Conservation law/Symmetry relation
d) Paul Dirac	_____	4. First to measure the speed of light
e) Ernest Rutherford	_____	5. Blackbody radiation and energy quanta
f) Max Planck	_____	6. $F = Ma$
g) Louis DeBroglie	_____	7. Quarks
h) Ole Rohmer	_____	8. Discovered the atomic nucleus
i) Murray Gell-Mann	_____	9. Predicted existence of antimatter
j) Erwin Schrodinger	_____	10. Model of the atom

Have a nice New Year!