PY 407 HW #2 (Sp09) (778061)

Fri Jan 23 2009 10:00 PM EST

Question
1 2 3 4 5 6 7

1. **Question Details** TR3 2.P.06. [427711]

In the 1887 experiment by Michelson and Morley, the length of each arm was 11 m. The experimental limit for the fringe shift was 0.005 fringes. If sodium light was used with the interferometer ($\lambda = 589$ nm), what upper limit did the null experiment place on the speed of the Earth through the expected ether?

- 3.47 km/s

2. **Question Details** TR3 2.P.12. [427751]

Determine the ratio $\beta = v/c$ for each of the following.

(a) A car traveling 100 km/h.

- 9.29e-08

(b) A commercial jet airliner traveling 300 m/s.

- 1.00e-06

(c) A supersonic airplane traveling mach 2.1. (Mach number = $v/v_{\text{sound}}$. Assume the speed of sound is 343 m/s.)

- 2.41e-06

(d) The space shuttle, traveling 21,000 km/h.

- 1.95e-05

(e) An electron traveling 33 cm in 2 ns.

- 0.552

(f) A proton traveling across a nucleus ($10^{-14}$ m) in $0.35 \times 10^{-22}$ s.

- 0.956

3. **Question Details** TR3 2.P.13. [427812]

Two events occur in an inertial system K as follows.

Event 1: $x_1 = a, t_1 = 2a/c, y_1 = 0, z_1 = 0$

Event 2: $x_2 = 2.5a, t_2 = 1.7a/c, y_2 = 0, z_2 = 0$

What is the velocity of the frame K’ in which these events appear to occur at the same time? Express the velocity vector using the variables $a$ and $c$ and the unit vectors, i, j, and k; for example, $2\mathbf{i} + 2\mathbf{j}$ is a vector which bisects the x and y axes.

- $-0.200c\mathbf{i}$

4. **Question Details** TR3 2.P.14. [427764]

An event occurs in system K’ at $x' = 2$ m, $y' = 3.7$ m, $z' = 3.7$ m, and $t' = 0$. System K’ and K have their axes coincident at $t = t' = 0$, and system K’ travels along the x axis of system K with a speed 0.94c. What are the coordinates of the event in system K?

$x = 5.86$ m

http://www.webassign.net/v4cgimbkustus@ncsu/assignments/preview...61&deployment=1377003&UserPass=a127aaaaf17bd4de17a0669573e413041
5. **Question Details** TR3 2.P.16. [427738]

Two events occur in an inertial system K as follows.

Event 1: \( x_1 = 0.5a, \ t_1 = 2a/c, \ y_1 = 0, \ z_1 = 0 \)
Event 2: \( x_2 = 2a, \ t_2 = 4.9a/c, \ y_2 = 0, \ z_2 = 0 \)

Is there a frame \( K' \) in which the two events occur at the same place? 

- [ ] yes
- [x] no

If "yes", then determine the velocity of \( K' \) relative to \( K \). If "no", then determine the velocity of the frame in which the two events are simultaneous. Express the velocity vector using the variables \( a \) and \( c \) and the unit vectors, \( i \), \( j \), and \( k \); for example, \( 2i + 2j \) is a vector which bisects the \( x \) and \( y \) axes.

\[ 0.5172c i \]

6. **Question Details** TR3 2.P.20. [427847]

Astronomers discover a planet orbiting around a star similar to our sun that is 15 light years away. How fast must a rocket ship go if the round trip is to take no longer than 30 years in time for the astronauts aboard?

\[ 0.707 \ c \]

How long will the trip take as measured on Earth?

\[ 42.4 \text{ yr} \]

7. **Question Details** TR3 2.P.31. [427849]

A spaceship is moving at a speed of \( 0.7c \) away from an observer at rest. A boy in the spaceship shoots a proton gun with protons having a speed of \( 0.8c \).

(a) What is the speed of the protons measured by the observer at rest when the gun is shot away from the observer?

\[ 0.962 \ c \]

(b) What is the speed of the protons measured by the observer at rest when the gun is shot toward the observer?

\[ 0.227 \ c \]
PY 407 HW #3 (Sp09) (778063)

Fri Jan 30 2009 10:00 PM EST

Question
1 2 3 4 5

1. **Question Details** TR3 2.P.59 revised [1061457]

A particle having a speed of $0.90c$ has a momentum of $10^{-16}$ kg·m/s. What is its rest mass?

1.61e-25 kg

2. **Question Details** TR3 2.P.66. [427719]

The Tevatron accelerator at the Fermi National Accelerator Laboratory (Fermilab) outside Chicago actually consists of 5 stages to sequentially boost protons to 1 TeV (1000 GeV). What is the speed of the proton at the end of each stage? Note: the numbers given in parentheses represent the total kinetic energy at the end of each stage.

- Cockcroft-Walton (750 keV) $0.04c$
- Linac (400 MeV) $0.713c$
- Booster (8 GeV) $0.99448c$
- Main ring or injector (150 GeV) $0.999981c$ (express to at least 5 decimal places)
- Tevatron itself (1 TeV) $0.9999956c$ (express to at least 7 decimal places)

3. **Question Details** TR3 2.P.70. [427773]

What is the speed of a deuteron when its kinetic energy is equal to 7 times its rest energy?

0.992 c

4. **Question Details** MI2 05.X.03.01 revised [1061466]

An alpha particle (a helium nucleus) is moving at a speed of $0.9986$ times the speed of light. Its mass is $(6.40 \times 10^{-27}$ kg).

(a) What is its rest energy? 5.76e-10 J

(b) Is it okay to calculate its kinetic energy using the formula $\frac{1}{2}mv^2$?

- Yes, because the formula $\frac{1}{2}mv^2$ for kinetic energy is always correct.
- Yes, because $v << c$.
- No, because this formula isn't valid for speeds near the speed of light.

(c) What is its kinetic energy? 1.03e-08 J

(d) Which is true for this situation?
The kinetic energy is much smaller than the rest energy.
The kinetic energy is approximately equal to the rest energy.
The kinetic energy is much bigger than the rest energy.

5. **Question Details TR3 2.P.78 revised [1061637]**

A test automobile of mass 950 kg moving at high speed crashes into a wall. The average temperature of the car is measured to rise by 0.6°C after the wreck. What is the change in mass of the car? (Assume the average specific heat of the automobile is close to that of steel, 0.11 cal·g⁻¹·°C⁻¹.)

![Mass change](image)

Where does this change in mass come from?

**Key:** The source of this energy is the internal energy of the arrangement of atoms and molecules prior to the collision.
PY 407 HW #7 (Sp09) (813861)

Fri Mar 13 2009 10:00 PM EDT

Question
1 2 3 4

1. **Question Details** TR3 5.P.42. [427707]

Find the minimum uncertainty in the speed of a proton having mass $1.67 \times 10^{-27}$ kg if we know the position of the proton to within $2 \times 10^{-15}$ m, that is, to about its own size.

1.58e+07 m/s

2. **Question Details** TR3 5.P.43. [427756]

An atom in an excited state of 4.9 eV emits a photon and ends up in the ground state. The lifetime of the excited state is $1.8 \times 10^{-13}$ s.

(a) What is the energy uncertainty of the emitted photon?

0.00183 eV

(b) What is the spectral line width (in wavelength) of the photon?

0.0944 nm

3. **Question Details** TR3 5.P.44. [427885]

An electron microscope is designed to resolve objects as small as 0.10 nm. What energy electrons must be used in this instrument?

151 eV

4. **Question Details** TR3 5.P.48. [427884]

The wave function of a particle in a one-dimensional box of width $L$ is $\Psi(x) = A \sin(\pi x / L)$. If we know the particle must be somewhere in the box, what must be the value of $A$? Express your answer in terms of $L$.

$\sqrt{2/L}$
1. **Question Details** TR3 6.P.11. [427810]
A wave function has the value $A \sin x$ between 0 and $\pi$, but zero elsewhere. Normalize the wave function and find the probability that the particle is between $x = 0$ and 0.87.

2. **Question Details** TR3 6.P.16. [427868]
An electron moves with a speed $v = 10^{-5}c$ inside a one-dimensional box ($V = 0$) of length 364 nm. The potential is infinite elsewhere. The particle may not escape the box. What approximate quantum number does the electron have?

3. **Question Details** TR3 6.P.17. [427787]
For the infinite square-well potential, find the probability that a particle in its seventh excited state is in each third of the one-dimensional box:

An electron is trapped in an infinite square-well potential of width 0.5 nm. If the electron is initially in the $n = 4$ state, what are the various photon energies that can be emitted as the electron jumps to the ground state? (List in descending order of energy. Enter 0 in any remaining unused boxes.)

Assignment Details

Name (AID): **PY 407 HW #8 (Sp09) (813862)**

Submissions Allowed: 8
Category: **Homework**
Code:
1. **Question Details** TR3 7.P.10. [427795]

For a 3p state give the possible values for each of the following orbitals. (Type your answer using hbar for \( \hbar \) and any integers as necessary. Multiple values must be entered from smallest to largest and separated by commas, for example -1,-hbar,0,hbar,1.)

\[
\begin{align*}
 n & = \quad 3 - \text{or-} +3 \\
 \varphi & = \quad 1 - \text{or-} +1 \\
 m_\varphi & = \quad -1,0,+1 - \text{or-} -1,0,1 \\
 L & = \quad \sqrt{2}\hbar \\
 L_z & = \quad -\hbar,0,hbar - \text{or-} -hbar,0,+hbar
\end{align*}
\]

\( L_x \) and \( L_y \) are unrestricted except for the following constraint:

- \( L_x^2 + L_y^2 = L^2 - L_z^2 \)
- \( L_x + L_y = L^2 - L_z^2 \)
- \( L_x^2 + L_y^2 = \sqrt{(L_x^2 - L_z^2)} \)
- \( L_x + L_y = \sqrt{(L_x^2 - L_z^2)} \)

2. **Question Details** hydrogen wave function [1093223]

Use tables 7.1 and 7.2 (on p. 245 of the textbook) to determine the wave function for a hydrogen atom with quantum numbers of \( \psi_{210} \): 

- \( \frac{1}{(a_0)^2} \frac{4}{\sin^2 \theta \sqrt{3}} \left( \frac{6 - r}{a_0} \right) \frac{e^{-\frac{r}{a_0}}}{\sqrt{\pi}} \left( \frac{1}{2} \right) \sqrt{3} \cos \theta \) 
- \( \frac{r}{a_0} \left( \frac{e^{-\frac{r}{a_0}}}{\sqrt{\frac{3}{2}}} \left( \frac{2}{a_0} \right)^2 \right) \left( \frac{1}{2} \right) \sqrt{3} \cos \theta \) 
- \( \frac{r}{a_0} \left( \frac{e^{-\frac{r}{a_0}}}{\sqrt{\frac{3}{2}}} \left( \frac{2}{a_0} \right)^2 \right) \left( \frac{1}{2} \right) \sqrt{3} \sin \theta \) 
- \( \frac{r}{a_0} \left( \frac{e^{-\frac{r}{a_0}}}{\sqrt{\frac{3}{2}}} \left( \frac{2}{a_0} \right)^2 \right) \left( \frac{1}{2} \right) \sqrt{3} \sin \theta \) 

3. **Question Details** TR3 7.P.15. [427731]

What is the smallest value that \( \varphi \) may have if \( \vec{r} \) is within 3.25° of the z axis?

\[ 310 \]
PY 407 HW #12 (Sp09) (852110)

Fri Apr 24 2009 10:00 PM EDT

1. **Question Details** TR3 7.P.34. [696813]

Find whether the following transitions (specified in terms of the initial and final quantum numbers \( n, \ell, m_\ell \) and \( m_s \)) are allowed, and if they are, find the energy involved (whether or not the transition is allowed) and whether the photon is absorbed or emitted for the hydrogen atom.

<table>
<thead>
<tr>
<th>transition</th>
<th>( B_z(T) )</th>
<th>allowed?</th>
<th>( \Delta E ) (eV)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) ( (3, 1, 1, 1/2) \rightarrow (6, 0, 0, 1/2) )</td>
<td>0</td>
<td>---Select---</td>
<td><strong>absorbed</strong></td>
</tr>
<tr>
<td>(b) ( (4, 3, 1, -1/2) \rightarrow (4, 2, 0, -1/2) )</td>
<td>-0.9</td>
<td>---Select---</td>
<td><strong>absorbed</strong></td>
</tr>
<tr>
<td>(c) ( (4, 3, -1, -1/2) \rightarrow (5, 3, -1, 1/2) )</td>
<td>0</td>
<td>---Select---</td>
<td><strong>unallowed</strong></td>
</tr>
<tr>
<td>(d) ( (5, 2, 0, -1/2) \rightarrow (5, 1, 1, -1/2) )</td>
<td>0.5</td>
<td>---Select---</td>
<td><strong>absorbed</strong></td>
</tr>
</tbody>
</table>

2. **Question Details** TR3 8.P.07. [427714]

The 3s state of Na has an energy of -5.14 eV. Determine the effective nuclear charge.

\[ 1.84 \text{ e} \]

3. **Question Details** TR3 8.P.09. [439999]

Select the correct atom for each electron configuration.

- \( 1s^22s^22p^6 \) ---Select--- \( B \)
- \( 1s^22s^22p^63s^1 \) ---Select--- \( Na \)
- \( 3s^23p^6 \) ---Select--- \( Ar \)

Assignment Details

Name (AID): PY 407 HW #12 (Sp09) (852110)