$T_{\text{on Earth}}$ = 3.0 hr - 7.49×10^{-6} s

Correct

Problem S4.52

this problem, we compare the strength of gravity to the strength of the electromagnetic (EM) force for two interacting electrons. Because both electrons are negatively arged, they will want to *repel* each other according to the EM force. Because electrons have mass, they will want to *attract* each other according to gravity. Let's see ich effect will dominate. You will need the following information for this problem:

1) The force law for gravitation is: $F_g = G\frac{M_1 M_2}{d^2}\left(G = 6.67\times10^{-11}\ \frac{\mathrm{N}\times\mathrm{m}^2}{\mathrm{kg}^2}\right)$ where M_1 and M_2 are the masses of the two objects, d is the distanc tween them, and G is the gravitational constant. (" N " is the abbreviation for *newton*, the metric unit of force.)

2) The force law for electromagnetism is: $F_{\mathrm{EM}} = k\frac{q_1 q_2}{d^2}\left(k = 9.0\times10^{9}\ \frac{\mathrm{N}\times\mathrm{m}^2}{\mathrm{Coul}^2}\right)$ where q_1 and q_2 are the charges of the two objects (in *coulombs*, the ndard unit of charge), d is the distance between them, and k is a constant. (" Coul " is an abbreviation for *coulomb*.)

3) The *mass* of an electron is $9.10\times10^{-31}\ \mathrm{kg}$.

4) The *charge* of an electron is $-1.6\times10^{-19}\ \mathrm{Coul}$.

rt A

Calculate the gravitational force, in newtons, that attracts the two electrons if a distance of $10^{-10}\ \mathrm{m}$ (about the diameter of an atom) separates them.

Express your answer in newtons to three significant figures.

ANSWER:

F_g = 5.52×10^{-51} N

Correct

rt B

Calculate the electromagnetic force, in newtons, that repels the two electrons at the same distance.

Express your answer in newtons to two significant figures.

ANSWER:

F_{EM} = 2.3×10^{-8} N

Correct

rt C

How many times stronger is the electromagnetic repulsion than the gravitational attraction for the two electrons?

Express your answer using two significant figures.

ANSWER:

$\frac{F_{\mathrm{EM}}}{F_{\mathrm{g}}}$ = 4.2×10^{42}

Correct

Problem S4.59

ppose you are running at a speed of about 10 $\mathrm{km/hr}$, but there is an uncertainty of 0.5 $\mathrm{km/hr}$ in your precise speed. Given your mass, you can calculate your mentum and the uncertainty of that momentum.

int: You'll need the first form of the uncertainty principle, $\begin{matrix}\text{uncertainty} \\ \text{in location}\end{matrix} \times \begin{matrix}\text{uncertainty} \\ \text{in momentum}\end{matrix} \approx \text{Planck's constant}.$ You can use the value of Planck's constant, $= 6.626 \times 10^{-34}\ \frac{\mathrm{kg} \times \mathrm{m}^2}{\mathrm{s}}$.)

rt A

What is the corresponding quantum limit to the measurement of your position? Assume that your mass is 50 kg.

Express your answer to three significant figures and include the appropriate units.

ANSWER:

$\Delta x =$ 9.54×10^{-35} m

Correct

rt B

Is this significant? Why or why not?

ANSWER:

- The uncertainty is very small compared to human size, but this effect could be significant.
- The uncertainty is much less than the Planck's constant, so this effect is not significant.
- The uncertainty is significant compared to the Planck's constant, so this effect is important.
- The uncertainty is very small compared to human size, so this effect is not significant.

Correct

Problem S4.60

u are conducting an experiment in which you can measure the location of individual electron collisions to within 10 $^{-10}$ m.

rt A

What is the theoretical limit to which you can simultaneously measure the momentum of those collisions? (Use the expression of the uncertainty principle in S4.3 Quantifying the Uncertainty Principle to make your estimate.)

Express your answer in kilograms times meter per second to three significant figures.

ANSWER:

$6.63\times10^{-24}\ \mathrm{kg}\times\mathrm{m/s}$

Correct

rt B

What is the uncertainty in the electron's speed? (The electron has a rest mass of 9.1×10^{-31} kg.)

Express your answer in meters per second to two significant figures.

ANSWER:

$7.3\times10^{6}\ \mathrm{m/s}$

Correct

Problem S4.55

e time it takes for a black hole to evaporate through the process of Hawking radiation can be calculated using the following formula, in which M is the mass of the bla le in kilograms and t is the lifetime of the black hole in seconds: $t = 10240\times\pi^2\frac{G^2M^3}{hc^4}\left(h = 6.63\times10^{-34}\ \frac{\mathrm{kg}\times\mathrm{m}^2}{\mathrm{s}},\right.$

$$\left.G = 6.67\times10^{-11}\ \frac{\mathrm{m}^3}{\mathrm{kg}\times\mathrm{s}^2}\right)$$

rt A

Use the formula to calculate the lifetime of a black hole with the mass of the Sun $(M_{\mathrm{Sun}} = 2.0\times10^{30}\ \mathrm{kg})$.

Express your answer in years to three significant figures.

ANSWER:

$t_{\text{black hole}}$ = 2.12×10^{67} yr

Correct

rt B

How does your answer compare to the current age of the universe? Assume the current age of the universe is about 10^{10} years.

Express your answer using three significant figures.

ANSWER:

$\frac{t_{\text{black hole}}}{t_{\text{universe}}}$ = 2.12×10^{57}

Correct

ore Summary:

ur score on this assignment is 101%.
u received 40.62 out of a possible total of 46 points, plus 6 points of extra credit.