Answers to Check-Yourself Questions

1 Yes. In Spiff's reference frame the missile hits the ship at 7 kajillion mph.

2 You should have answered "2×10^8 m." That's what Galileo would have said, anyway. If you said something else, how can you justify it?

3 Velocity transforms using the same equations that transform position from one coordinate system to the other. In fact all vectors do. Speed, which is the magnitude of velocity, is a scalar, and scalar quantities are the same in both coordinate systems.

4 Out of phase

5 3.14×10^{-19} W

6 $\psi(x) = A \sin\left(\frac{\sqrt{2mE}}{\hbar} x\right) + B \cos\left(\frac{\sqrt{2mE}}{\hbar} x\right)$

7 You should have found that the velocity of the wave is $v/2$.

8 A classical particle would bounce back at $x = 0$ and start moving left.

9 $E = (a^2 + b^2)(\pi^2 \hbar^2)/(2mL^2)$

10 Polar to Cartesian: $x = \rho \cos\phi$, $y = \rho \sin\phi$

Cartesian to polar: $x^2 + y^2 = \rho^2$, $\tan\phi = y/x$

11 Higher, aka less negative. If you treat those inner electrons as literally a sphere of charge around the nucleus, their electric field perfectly cancels out the field from two of the protons. So instead of a three-proton electric field (very negative energy) you get a one-proton electric field (less negative energy).

12 1

13 About 50%

14 You should have found that transferring energy from S_2 to S_1 will decrease the overall entropy of the system, so that is not likely to happen. Our point here is to disabuse you of the common misconception that energy always tends to flow from high-energy systems to lower-energy systems. In this artificial example, and in many natural examples, it flows the other way.

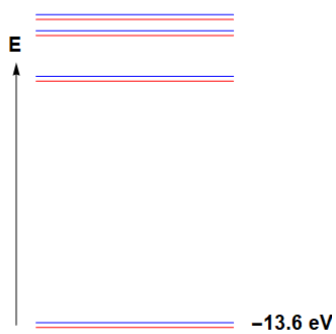
15 It has 0 in about 4 million microstates, and ϵ in about 160,000 microstates.

16 $0.156\ k_B T$

17 1/4

18 There is only one: the microstate "most of the particles have zero energy, but one of them has energy ϵ." For bosons, unlike distinguishable particles, you cannot meaningfully ask the question "which one?"

19 Each energy level is split into two, which we've indicated with red and blue lines for the bonding and antibonding states.



20 $3Nk_B T$

21 2.3×10^{-13} J

22 Before: 1801 MeV After: 1806 MeV

23 That would be easy to detect, since balls don't actually fall to the right. And even if a ball happens to be moving to the right, it doesn't continually speed up in that direction.

24 20.4 light-years

25 Yes. For instance, Mark 1 moved one inch in one second, so its average speed is one inch per second. Mark 2 moved two inches in one second, so its average speed is two inches per second…and so forth.

26 $\frac{1}{2} m_X \dot{r}^2 - G\frac{m_X M_S}{r} = C$

27 $[(13.8 \text{ Gyrs})/(1 \text{ s})]^{2/3} = 6 \times 10^{11}$

28 Somewhat more than 10 to the 200 million!