May 1, 2008

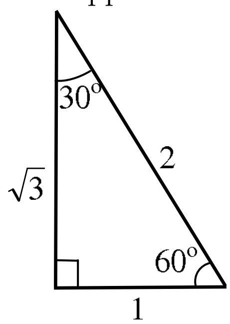
Physics 262: Physics for Life Sciences II
Section 801: Third Midterm Test Solutions

Section A

1. B	5. C	9. D	13. D	17. C	21. C
2. B	6. C	10. A	14. B	18. C	
3. D	7. C	11. D	15. D	19. B	
4. C	8. B	12. A	16. C	20. B	

Section B

1. A charge of 0.2 C is moving vertically in a field of 4 T that is oriented at 30° from vertical (that is, the $\vec{\mathbf{B}}$ vector makes an angle of 30° with respect to the vertical direction). What speed must the charge have such that the magnitude of the magnetic force acting on it is 10 N? The following triangle might be useful in calculating the speed. Also recall that sine = opposite over hypotenuse.



Answer:

The magnitude of the magnetic force is given by $|\vec{\mathbf{F}}_{\text{magnetic}}| = |q|\, vB\sin\theta$, where q is the charge, v is the speed of the charge, B is the magnitude of the magnetic field and θ is the angle between the $\vec{\mathbf{B}}$ and $\vec{\mathbf{v}}$. Therefore

$$v = \frac{|\vec{\mathbf{F}}_{\text{magnetic}}|}{|q|\, B\sin\theta}.$$

From the triangle shown in the problem, $\sin(30^\circ) = \frac{1}{2}$. Substituting the values given in the problem yields

$$v = \frac{10\,\mathrm{N}}{(0.2\,\mathrm{C})\cdot(4\,\mathrm{T})\cdot\frac{1}{2}} = \frac{10}{0.4}\,\mathrm{m/s} = \frac{100}{4}\,\mathrm{m/s} = \boxed{25\,\mathrm{m/s}}.$$

2. A 0.5-kg piece of metal at a temperature of 70°C is placed into 1.0-kg of water at 20°C. When the metal and water come to thermal equilibrium, both are at 30°C. The specific heat of water is $4.2\,\mathrm{kJ}/(\mathrm{kg}\cdot\mathrm{C^o})$. What is the specific heat of the metal? (Assume that no thermal energy has escaped from the water and metal into the environment.)

   Answer:

   By conservation of energy,

$$m_{\mathrm{m}}c_{\mathrm{m}}\,\Delta T_{\mathrm{m}} + m_{\mathrm{w}}c_{\mathrm{w}}\,\Delta T_{\mathrm{w}} = 0,$$

   where the subscripts "m" and "w" refer to the metal and water, respectively. Since we want to find the specific heat of the metal, we isolate c_{m} on one side of the equation. A little algebra gives

$$c_{\mathrm{m}} = -\left(\frac{m_{\mathrm{w}}}{m_{\mathrm{m}}}\right)\left(\frac{\Delta T_{\mathrm{w}}}{\Delta T_{\mathrm{m}}}\right)c_{\mathrm{w}}.$$

   Substituting the ratios of the masses, $m_{\mathrm{w}}/m_{\mathrm{m}} = 1\,\mathrm{kg}/(0.5\,\mathrm{kg}) = 2$, the ratios of the temperature changes $\Delta T_{\mathrm{w}}/\Delta T_{\mathrm{m}} = 10\,^{\circ}\mathrm{C}/(-40\,^{\circ}\mathrm{C}) = -1/4$, and the specific heat of water gives

$$c_{\mathrm{m}} = -(2)\times\left(-\frac{1}{4}\right)\times 4.2\,\mathrm{kJ}/(\mathrm{kg}\cdot\mathrm{C^o}) = \boxed{2.1\,\mathrm{kJ}/(\mathrm{kg}\cdot\mathrm{C^o})}\,.$$