Score (out of 10)	Distinguishing Characteristics	Summary
10	• Demonstrates a confident understanding of the concepts and explains those concepts clearly. • Clearly written throughout. • Contains almost no errors in spelling, punctuation, or grammar. • Contains enough development to provide a truly helpful explanation to fellow learners.	The work shows a correct understanding of the concepts and explains them clearly to a new learner.
9	• Demonstrates a confident understanding of the concepts and explains those concepts clearly. • Successful in teaching the concepts, but may have more minor errors or somewhat less development than a 10.	
8 or 7	• Reveals to the instructor that the writer probably understands the concepts, but lacks clarity in the writing or lack of fully developed explanations; the work would not teach the concept to new learners. • Usually "you know what I mean" essays: someone who already understands the concepts can tell that the writer probably does, too, but someone who does not already understand the concepts would not learn anything from the explanation. • Or, clearly written essays that have misunderstandings of the physics concepts. • Or, accurate essays full of sentence-level errors.	The work is generally correct but not clearly explained. - or - The work contains misunderstandings but is clearly written.
6 or 5	• Unsuccessful either because the writer fails to understand the physics concepts, • or because the number of errors or omitted parts is so high that the instructor cannot determine how much the writer understands, • or because the explanations lack even minimum development.	The concepts are misunderstood. - or - The work is so poorly written (or absent) that the reader can't understand.
0	• Nothing is turned in.	

Adapted from *Holistic Scale for Grading Physics Microthemes*, Engaging Ideas by John C. Bean.

Example Graded Problem

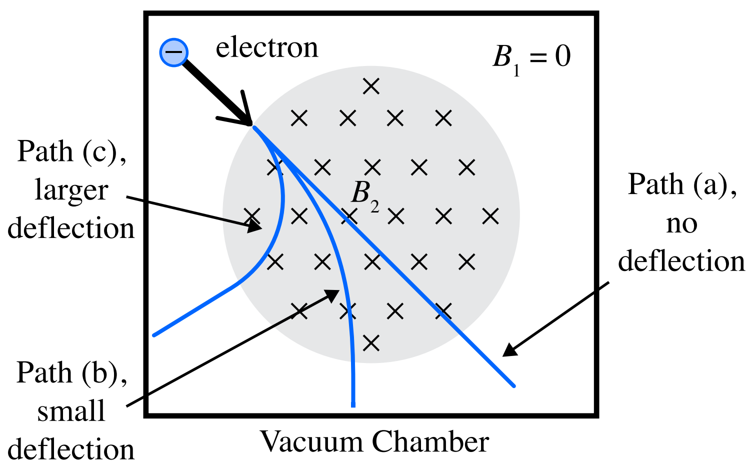
Most of the air molecules are pumped out of a chamber. Thus, a charged particle moving through the chamber will not lose a noticeable amount of energy in collisions with air molecules. There is a region in the center of the chamber that can have a uniform magnetic field pointing into the paper that is caused by an external magnet.

a) Sketch the electron's path if the magnetic field is zero throughout the evacuated region so that $B_1 = B_2 = 0$. Does the velocity of the electron change? Does its speed change? Does its direction change? Why or why not?

b) Sketch the electron's path if the magnetic field B_2 in the central area of the chamber is uniform but fairly weak and the magnetic field B_1 outside the circle is zero. Does the velocity of the electron change? Does its speed change? Does its direction change? Why or why not?

c) Sketch the electron's path if the magnetic field in the central area of the chamber is uniform and very strong. Does the velocity of the electron change? Does its speed change? Does its direction change? Why or why not?

d) What would happen to the shape of the path in part (c) if the particle were a negative ion having a much greater mass than the electron but still having the same net negative charge as the electron?



Here are 3 different possible student answers. Assume all 3 are accompanied by the same drawing (to the right).

10 point answer "Contains enough development to provide a truly helpful explanation to fellow learners."	a) The electron is undeflected and does not change its speed or velocity because there is no magnetic force on it when $B_2 = 0$. b) Since there is a magnetic field, B_2, the magnetic force $\vec{F}^{mag} = q\vec{v} \times \vec{B}$ (causes the electron to be slightly deflected in the downward direction, as shown, while it is traveling through the magnetic field. The electron does not change its speed, only its direction. The direction of the force was obtained by using the right-hand rule and then reversing the direction of the small magnetic force to account for the fact that the electron has a

	negative charge on it. After the electron leaves the magnetic field region, it starts traveling straight as shown in the diagram. c) The magnetic field is much stronger than in part (b), so the deflection is more pronounced. This is from the equation which relates the centripetal force magnitude to radius, $F^{net} = \frac{mv^2}{r}$, so the larger the force, the smaller the radius. Again, the electron's speed doesn't change, only its direction. After the electron leaves the magnetic field region, it starts traveling straight as shown in the diagram. d) The magnetic force on the ion would be exactly the same as in part (c), but since the negative ion is more massive than the electron, it does not accelerate as much and so it deflects less than an electron would. Using the equation in part c, F stays the same but m increases, so r must increase as well (v, the speed, does not change).
8 point answer "The work would not teach the concept to new learners."	a) With no magnetic force, the electron's path doesn't change. b) Now that there is a magnetic force, the electron will curve down, by RHR. Speed doesn't change, but direction does. c) If the magnetic force gets much stronger, then the electron will follow a smaller curve. d) The more massive ion will not accelerate as much, so the curve will be larger.
6 point answer "Explanations lack even minimum development."	a) Nothing changes. b) Velocity changes, speed doesn't change, direction changes. c) Same as part b, but more. d) The path would be less curved.

All three answers are correct, but only the first one provides a complete explanation. A fellow student reading the answer should be able to figure out exactly what the question was, learn which physical concepts are required to solve the problem, and apply the concepts properly.