A PROTON (CHARGE 1.60×10^{-19}C, MASS 1.67×10^{-27}kg) IS PLACED 18cm FROM A ROD OF UNIFORM CHARGE DENSITY $\lambda = 5\times10^{12}\,Cm^{-1}$. THE INITIAL VELOCITY OF THE CHARGE IS $1.5kms^{-1}$ TOWARDS THE ROD BUT IT STOPS AT A DISTANCE b FROM THE ROD. KINETIC ENERGY IS $\frac{1}{2}mv^2$ FOR MASS m MOVING AT VELOCITY v.

(1) WHAT IS THE ELECTRIC FIELD OF THE ROD?

(2) HENCE: WHAT IS THE DISTANCE b?

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(1) E-FIELD OF ROD

(a) DRAW A GAUSSIAN SURFACE THAT ENCLOSES THE ROD SUCH THAT $\vec{E}.d\vec{A} = EdA$ AT ALL POSITIONS (SO THAT THE ANGLE BETWEEN $\vec{E}$ AND $d\vec{A}$ IS ALWAYS 0 AND $\cos\theta = 1$)

(b) WE ARE USING A CONTINUOUS CHARGE DISTRIBUTION, SO WRITE Q IN TERMS OF λ, THE (ONE-DIMENSIONAL) CHARGE DENSITY ON THE ROD

(c) USE GAUSS'S LAW TO FIND THE ELECTRIC FIELD IN TERMS OF THE FLUX THROUGH YOUR GAUSSIAN SURFACE, $\oint_S \vec{E}.d\vec{A} = \frac{Q_{IN}}{\varepsilon_0}$

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(2) THE DISTANCE b

(a) SKETCH THE ROD AND THE DISTANCES a AND b

(b) USE $\Delta V = V_a - V_b = \int_a^b \vec{E}.d\vec{l}$ TO FIND THE CHANGE IN POTENTIAL

(c) CHECK THAT ΔV IS BEHAVING AS IT SHOULD. DOES $\vec{E}$ POINT FROM HIGH TO LOW POTENTIAL?

(d) USE $\Delta U = q\Delta V$ TO WRITE THE POTENTIAL IN TERMS OF THE POTENTIAL ENERGY

(e) USE THE FACT THAT ALL POTENTIAL ENERGY BECAME KINETIC ENERGY TO RELATE THE KINETIC ENERGY AND ΔV. HENCE FIND THE DISTANCE.