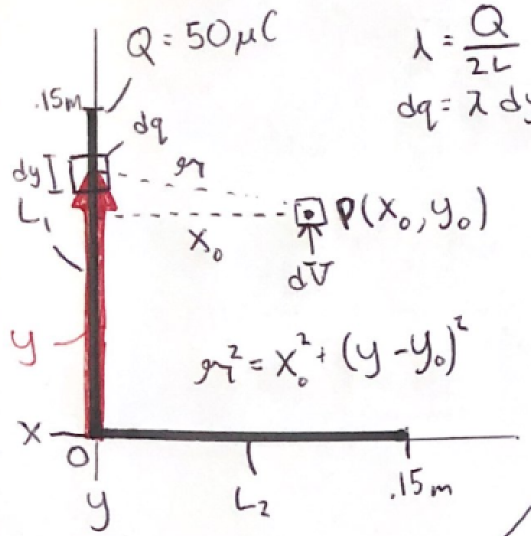
Christopher Hunt
PH213

# HIP 4

A wire bent to make the shape of an L .15 m on each side is charged to 50mC.

a) Derive an analytical function that finds the potential everywhere.




$$\bar{V}_1 = \int d\bar{V}$$

$$\bar{V}_1 = \int \frac{1}{4\pi\varepsilon_0} \cdot \frac{dq}{r}$$

$$\boxed{\bar{V}_1 = \frac{1}{4\pi\varepsilon_0} \int_0^L \frac{\lambda\, dy}{\sqrt{x_0^2 + (y-y_0)^2}}}$$

$$\bar{V}_2 = \int d\bar{V}$$

$$\bar{V}_2 = \int \frac{1}{4\pi\varepsilon_0} \cdot \frac{dq}{r}$$

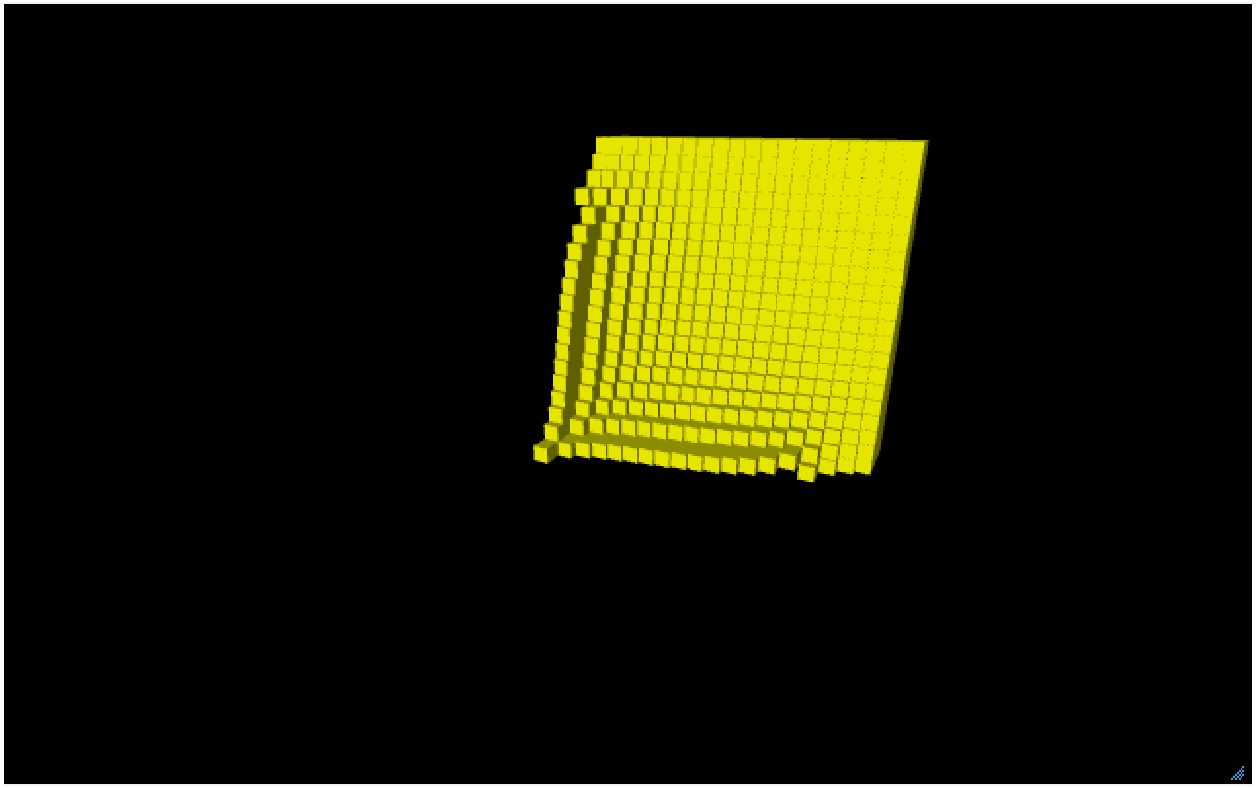
$$\boxed{\bar{V}_2 = \frac{1}{4\pi\varepsilon_0} \int_0^L \frac{\lambda\, dx}{\sqrt{y_0^2 + (x-x_0)^2}}}$$

$$\bar{V}_{tot} = \bar{V}_1 + \bar{V}_2$$

b) Create a VPython program that uses numerical integration to calculate the potential at positions one cm apart everywhere within a space 20cm by 20 cm large that contains the charged wire.

```
GlowScript 3.1 VPython
## Electric potential of a bent charged wire ##
## Constants ##
k=1/(4*pi*8.85*10**-12) #C2/N*m2
Q=50*10**-6 # C
L=15 #Cm
n=30
dq=Q/n #C
step=1
Ix=0
Iy=0


## Position of interest ##
iPos=vec(Ix,Iy,0)



## Numerical calculator for electric potential in wire along the x-axis ##
def dVxWire(A):
        dVx=0
        dx=0
        while dx<=L:
        dVx=dVx+((k*dq)/mag(A-vec(dx,0,0)))
        dx=dx+step

        return(dVx)


## Numerical calculator for electric potential in wire along the y-axis ##
def dVyWire(A):
        dVy=0
        dy=0
        while dy<=L:
        dVy=dVy+((k*dq)/mag(A-vec(0,dy,0)))
        dy=dy+step

        return(dVy)

## Nested loop that moves the interested position along the positive x axis and ##
##positive y axis, finding the electric potential at that point##
for x in range(0,20,step):
        rate(100000000)
        for y in range(0,20,step):
        rate(100000000)
        iPos=vec(Ix,Iy,0)
        ePot=dVxWire(iPos)+dVyWire(iPos)
        box(pos=iPos+vec(0,0,ePot/2),size=vec(1,1,(ePot)),color=color.yellow)
        Iy=Iy+step
        print("Position: ",iPos,"   Electric Potential: ",ePot)
        Iy=0
        Ix=Ix+step
```

```
GlowScript 3.1 VPython
## Electric potential of a bent charged wire ##
## Constants ##
k=1/(4*pi*8.85*10**-12) #C2/N*m2
Q=50*10**-6 # C
L=15 #Cm
n=30
dq=Q/n #C
step=1
Ix=0
Iy=0


## Position of interest ##
iPos=vec(Ix,Iy,0)



## Numerical calculator for electric potential in wire along the x-axis ##
def dVxWire(A):
    dVx=0
    dx=0
    while dx<=L:
        dVx=dVx+((k*dq)/mag(A-vec(dx,0,0)))
        dx=dx+step

    return(dVx)


## Numerical calculator for electric potential in wire along the y-axis ##
def dVyWire(A):
    dVy=0
    dy=0
    while dy<=L:
        dVy=dVy+((k*dq)/mag(A-vec(0,dy,0)))
        dy=dy+step

    return(dVy)

## Nested loop that moves the interested position along the positive x axis and ##
##positive y axis, finding the electric potential at that point##
for x in range(0,20,step):
    rate(100000000)
    for y in range(0,20,step):
        rate(100000000)
        iPos=vec(Ix,Iy,0)
        ePot=dVxWire(iPos)+dVyWire(iPos)
        box(pos=iPos+vec(0,0,ePot/2),size=vec(1,1,(ePot)),color=color.yellow)
        Iy=Iy+step
        print("Position: ",iPos,"   Electric Potential: ",ePot)
    Iy=0
    Ix=Ix+step
```



```
Position:  < 4, 10, 0 >   Electric Potential:  6.34968e+4 J/C
Position:  < 4, 11, 0 >   Electric Potential:  6.08174e+4 J/C
Position:  < 4, 12, 0 >   Electric Potential:  5.79543e+4 J/C
Position:  < 4, 13, 0 >   Electric Potential:  5.48393e+4 J/C
Position:  < 4, 14, 0 >   Electric Potential:  5.14452e+4 J/C
Position:  < 4, 15, 0 >   Electric Potential:  4.78262e+4 J/C
Position:  < 4, 16, 0 >   Electric Potential:  4.41417e+4 J/C
Position:  < 4, 17, 0 >   Electric Potential:  4.06061e+4 J/C
Position:  < 4, 18, 0 >   Electric Potential:  3.73836e+4 J/C
Position:  < 4, 19, 0 >   Electric Potential:  3.45386e+4 J/C
Position:  < 5, 0, 0 >   Electric Potential:  Infinity J/C
Position:  < 5, 1, 0 >   Electric Potential:  1.13009e+5 J/C
Position:  < 5, 2, 0 >   Electric Potential:  9.44013e+4 J/C
Position:  < 5, 3, 0 >   Electric Potential:  8.44369e+4 J/C
Position:  < 5, 4, 0 >   Electric Potential:  7.78853e+4 J/C
Position:  < 5, 5, 0 >   Electric Potential:  7.30934e+4 J/C
Position:  < 5, 6, 0 >   Electric Potential:  6.93123e+4 J/C
Position:  < 5, 7, 0 >   Electric Potential:  6.61371e+4 J/C
Position:  < 5, 8, 0 >   Electric Potential:  6.33213e+4 J/C
Position:  < 5, 9, 0 >   Electric Potential:  6.07008e+4 J/C
Position:  < 5, 10, 0 >   Electric Potential:  5.8158e+4 J/C
Position:  < 5, 11, 0 >   Electric Potential:  5.56043e+4 J/C
Position:  < 5, 12, 0 >   Electric Potential:  5.29732e+4 J/C
Position:  < 5, 13, 0 >   Electric Potential:  5.02232e+4 J/C
Position:  < 5, 14, 0 >   Electric Potential:  4.73466e+4 J/C
Position:  < 5, 15, 0 >   Electric Potential:  4.43814e+4 J/C
```

c) Use your results in part a and part b to conduct a reasonableness test.

To test the reasonableness I will exam the point at P = (.05, .05) m

The calculation done numerically gives a result of V=7.30934 x $10^4$ J/C

The calculation done analytically gives a result of V=6.97 x $10^6$ J/C

$$P = (.05, .05)$$

$$V_{tot} = \frac{\lambda}{4\pi\varepsilon_0}\left( \int_0^L \frac{1\,dy}{\sqrt{.05^2+(y-.05)^2}} + \int_0^L \frac{1\,dx}{\sqrt{.05^2+(x-.05)^2}} \right)$$

$$V_{tot} = \frac{\lambda}{4\pi\varepsilon_0} \cdot \left( 2 \cdot \left( \sinh^{-1}(10(2x-.1)) \right) \Big|_0^{.15} \right)$$

$$\boxed{V_{tot} = 6.97 \times 10^6 \ \frac{J}{C} \ \text{at point } P}$$

| GORY | PLARY (1.5) | MPLISHED (1) | LOPING (0.5) | GENT (0) |
|---|---|---|---|---|
| Statement and tion | arning tool for our class is written | blem is clearly presented for reader in n words. | blem is directly copied or is hard . | p into some calculation |
| | etch could be dropped into a novel as it stands. | a clear sketch, larger than a credit the problem set up with important and data noted | some sketch of the problem | etch? |
| s Tools | iate physics tools are correlated ercise in textbook quality and | iate physics tools are correlated to the . Appropriate tools include: pictures, onservational laws utilized, etc… | hysics tools are correlated to the . | e a few equations written. |
| n Solution tation | is very clearly presented with g asides or annotations | is complete and clearly presented no significant intuitive demands on the | solution I have to read between . | es version of solution with only nts present |
| | ution can serve as solution | g is larger than a credit card, tion is fluid, notation used is clear. | gure the path of your solution with | read it. |
| | | correctly given | ions & quantities are presented s | nits at the results |
| n | | | close | ot reasonable |
| ant Figures | | Sig Figs | ffort to use correct significant | he number from the calculator |
| nableness | s more than one type of ableness check. | he clear rationale for appropriateness of tion in the setting | that the answer is reasonable but sn't given any evidence | ssion |
| Graded | | | e | ut your self-assessment is from mine by at least two steps. |