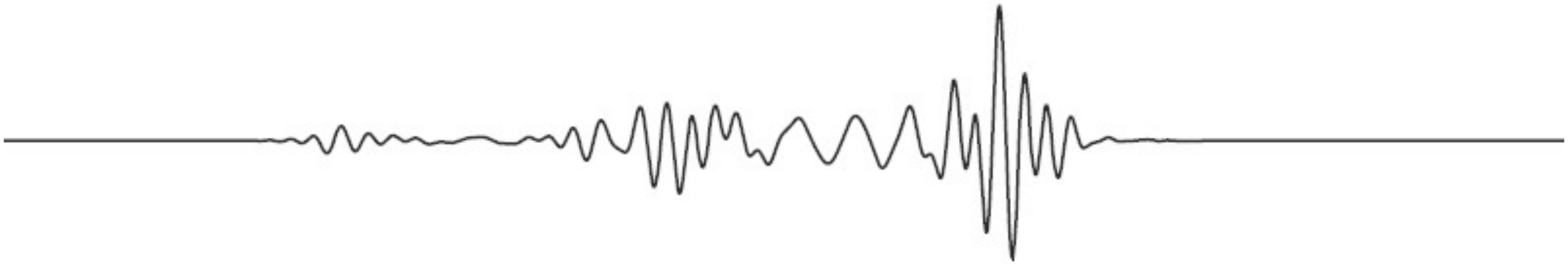
Pensamiento Computacional

Algunos consideraciones sobre los cursos de Física II y III para ingeniería en el semestre 2023-1



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Lo que tenemos

Estudiantes con edades entre los 16 y 18 años

Déficit de atención

Incapacidad para memorizar

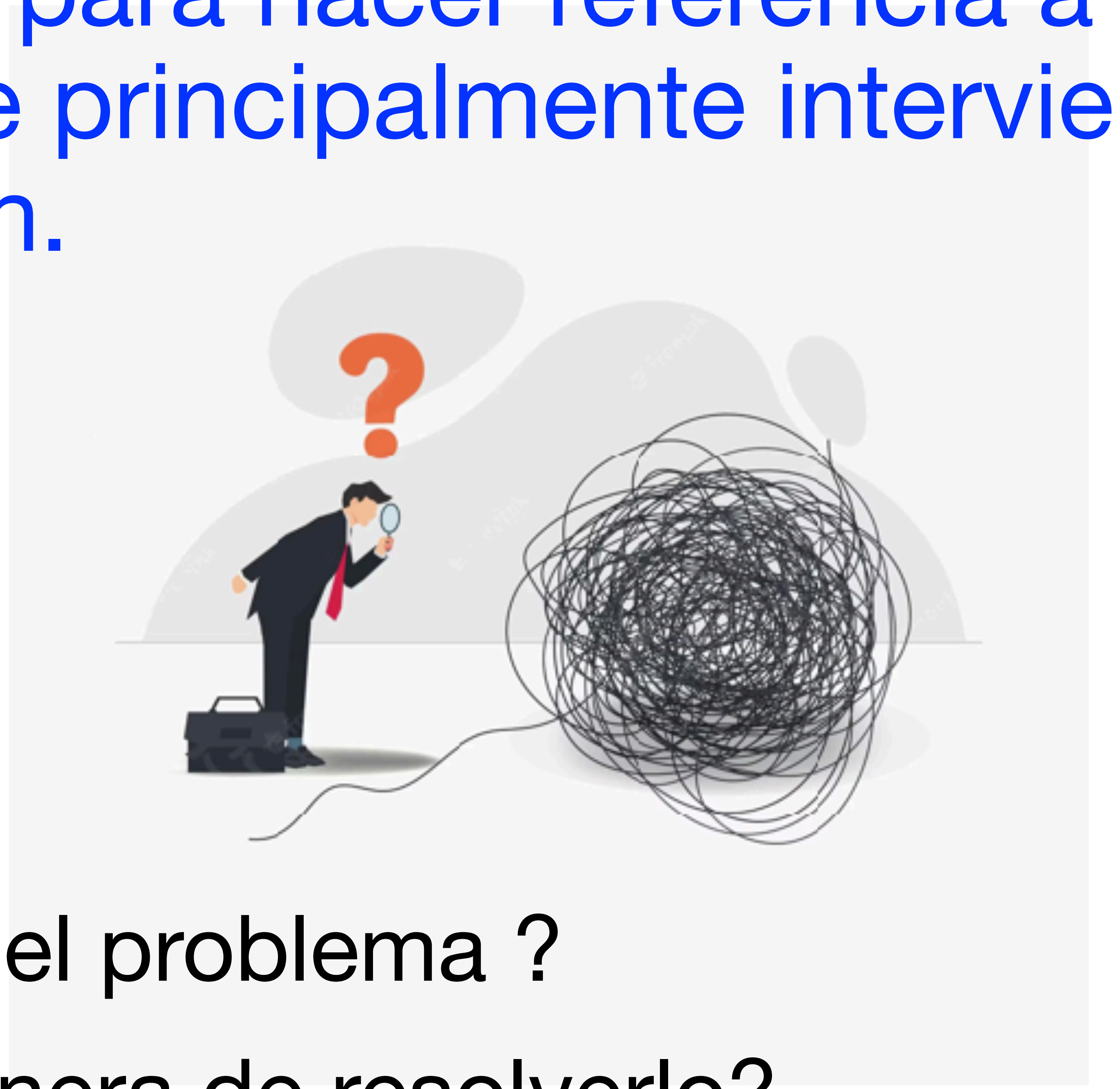
Falta de motivación

Pensamiento Computacional (PC)

El término es relativamente nuevo en el léxico de los objetivos de aprendizaje, fue acuñado en un ensayo por Jeannette Wing (2006)*

"A la lectura, la escritura y la aritmética, debemos agregar el pensamiento computacional a la capacidad analítica de cada niño".

El PC es utilizado para hacer referencia a técnicas y metodologías de resolución de problemas, donde principalmente intervienen saberes que provienen de las ciencias de la computación.



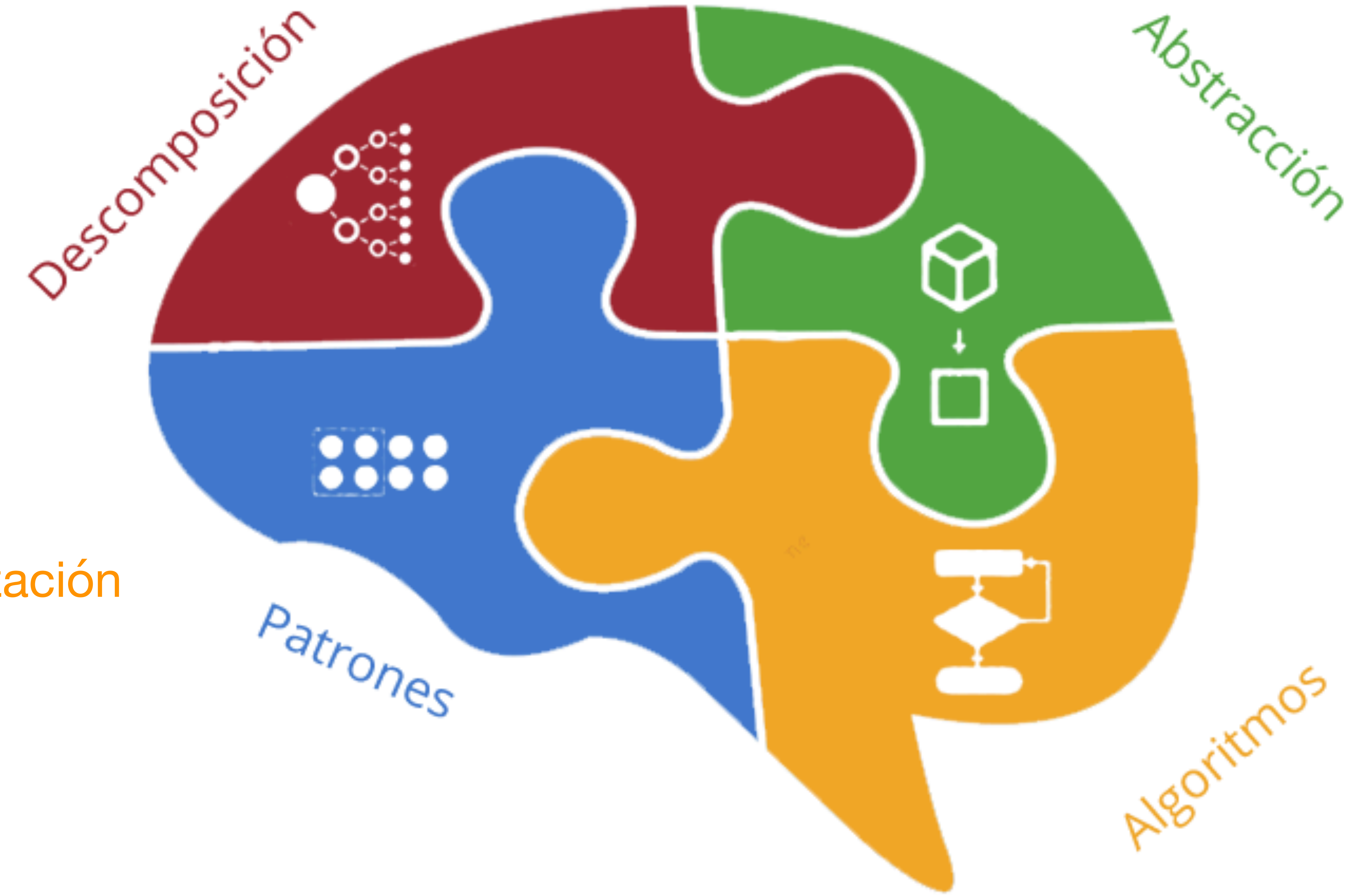
¿Qué dificultad tiene el problema ?

¿Cuál es la mejor manera de resolverlo?

¿Una solución aproximada es lo suficientemente buena?

* Computational Thinking
Jeannette M. Wing
Article in Communications of the ACM · March 2006
DOI: 10.1145/1118178.1118215

Las capacidades que están vinculadas al PC, se pueden resumir en:



Evaluación

Generalización

Prácticas a implementar con el PC

Prácticas de datos

Prácticas de resolución de problemas computacionales

Prácticas de modelado y simulación

Pensamiento sistémico

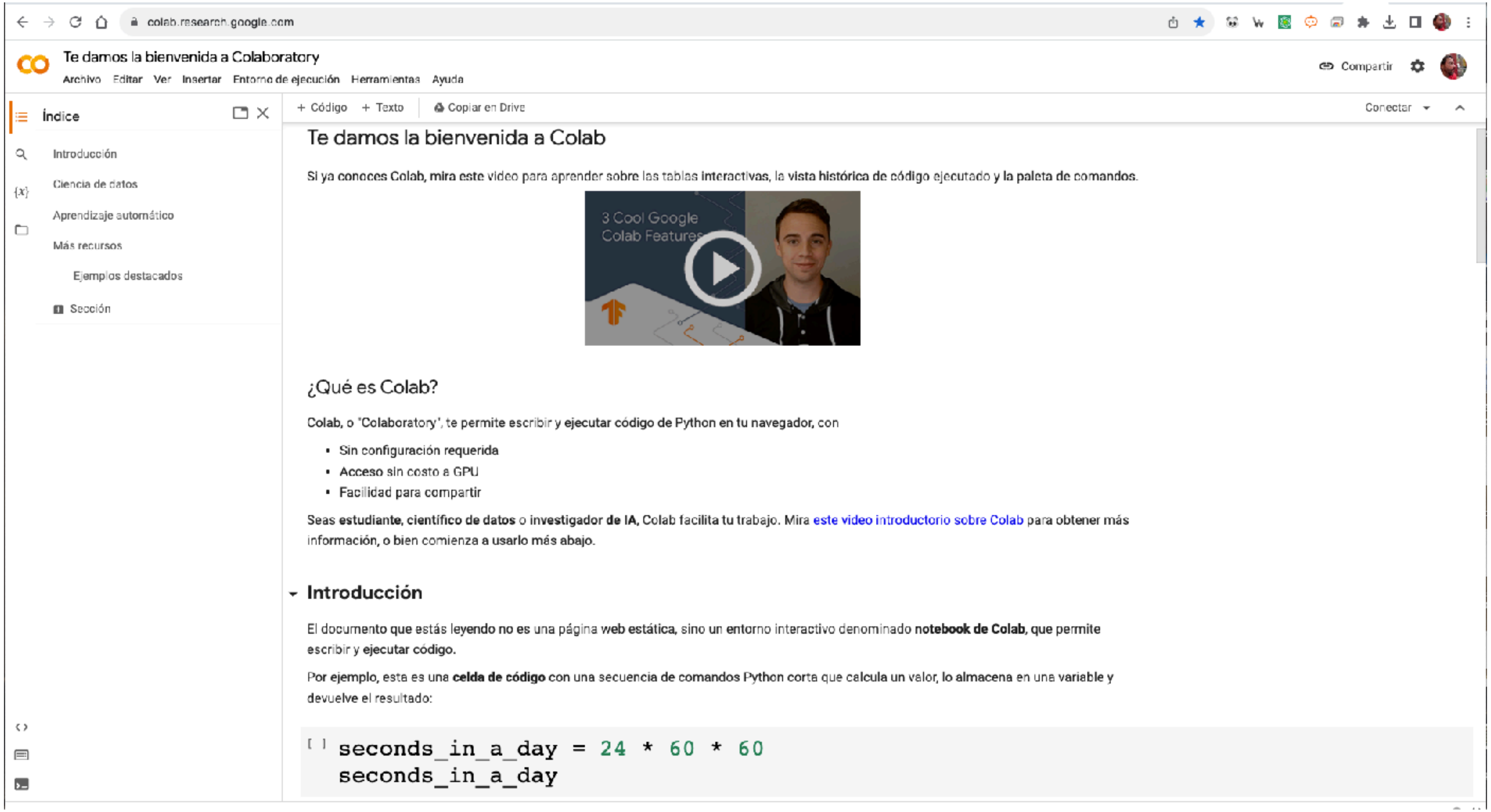
Metodología

Prácticas de modelado y simulación

Un programa de manipulación simbólica

1) Desde la primera semana se introducen en el uso de una **calculadora inteligente**:

Sympy en Python - Colab de Google



```python
a,b,c,d =symbols("a b c d")
```

```python
ex= a**2+b**3
ex
```

$$a^2 + b^3$$

```python
c =sqrt(a**3+1/d**2)
c
```

$$\sqrt{a^3 + \frac{1}{d^2}}$$

```python
ex.subs(b,c)
```

$$a^2 + \left(a^3 + \frac{1}{d^2}\right)^{\frac{3}{2}}$$

SymPy

Wolfram Mathematica

Maple

MATLAB

SymPy es una biblioteca de Python para matemáticas simbólicas. Su propósito es llegar a ser un sistema de álgebra por computadora (CAS) completo manteniendo el código tan simple como sea posible para poder ser legible y extensible de manera fácil.

Primeros pasos a través de un tutorial

Tutorial_V1_5.ipynb

Archivo Editar Ver Insertar Entorno de ejecución Herramientas Ayuda Se guardaron todos los cambios

Comentar Compartir

+ Código + Texto Conectar

```
# 30/5/2023
import sympy
from sympy import *
from sympy.plotting import plot
__version__
```

'1.11.1'

1) Sintáxis básica

Si queremos calcular: $3! + 2^3 - 1$ debemos escibir:

```
factorial(3) + 2**3 - 1
```

13

El valor de: $\sqrt{8}$

```
sqrt(8)
```

$2\sqrt{2}$

Si queremos el valor numérico podemosmos usar **float**

```
float(sqrt(8))
```

2.8284271247461903

El mundo matemático vs el mundo informático

Tutorial_V1_5.ipynb

Archivo Editar Ver Insertar Entorno de ejecución Herramientas Ayuda Se guardaron todos los cambios

Comentar Compartir

+ Código + Texto Conectar

Consideremos ahora una combinación de operaciones matemáticas

$$\frac{\sqrt{8}}{3} + \ln(e+1) + \log_{10}(3) + e^{\pi^2} + (e^{\pi})^2 - 6!\sin\left(\frac{\pi}{3}\right) + \sqrt{-1}$$

```
[ ] sqrt(8)/3 + log(E+1)  + log(3, 10)  + exp(pi**2) + exp(pi)**2 - factorial(6)*sin(pi/3) + sq
```

$$-360\sqrt{3} + \frac{\log(3)}{\log(10)} + \frac{2\sqrt{2}}{3} + \log(1+e) + e^{2\pi} + e^{\pi^2} + i$$

Aquí aprenderemos un atajo. Queremos reutilizar la última salida en el siguiente comando.

Para hacer esto se utiliza _ como el argumento del comando. En este caso el comando que utilizaremos es **round**, que nos dará el valor númerico de la expresión anterior con tres decimales

```
[ ] round(_,3)
```

$19248.376 + i$

También se entiende con los números imaginarios, por ejemplo: $\sqrt{-1} + 2i$

```
[ ] sqrt(-1)+2*I
```

$3i$

$e^{\pi i} + 1 = 0$

```
[ ] exp(pi*I)+1
```

0

2) Quices y algo más

- Un primer quiz con un solo problema a resolver
- Ese mismo día se les resuelve el problema en el tablero
- Luego se le comparte la solución pero en un Notebook usando SymPy

Para el segundo quiz, y los siguientes, se le pide al estudiante resolverlo de manera presencial y luego nuevamente en un Notebook, esta vez como taller para la casa.

El primer examen parcial es un examen estándar. La parte de taller consiste en que el estudiante debe resolverlo luego en un Notebook en casa.

3) Se repite la receta con el resto de quices y parciales.

Todos los Notebook se reúnen como la nota del taller.

...cular q_2 sobre q_1

1|10

$e^- = -1.6 \times 10^{-19}$

micro coulomb

$p = 1.6 \times 10^{-19}$

$k = 9 \times 10^{9}$

$r_1 < 4{,}0,\ -2{,}0,\ 5{,}0 > cm$ (x, y, z)

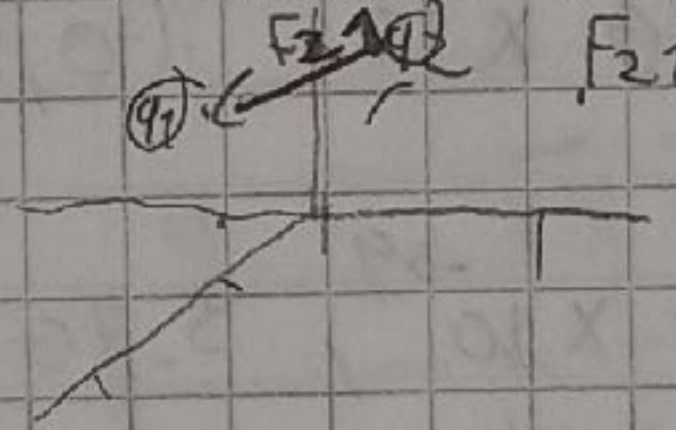
$r_2 < 8{,}0,\ 5{,}0,\ 4{,}0 > cm$ (x, y, z)

...as

$$F_{21} = \frac{(9\times10^{9})(q_1)(q_2)}{\|\vec{r}\|^2}\ \hat{r}_{21} \quad r_1 - r_2$$

$q_1 = 2{,}0\ \mu C = 3.2 \times 10^{-25}$

$q_2 = 4{,}0\ mC = 6.4 \times 10^{-25}$



F_{21} la fuerza que ejerce q_2 sobre q_1

rpta (1) atrás

$\Rightarrow dv = r\,dr\,d\theta\,dz$

$$= \int \alpha r^2\,dr\,d\theta\,dz = \int_0^r \alpha r^2\,dr \int_0^{2\pi} d\theta \int_0^L dz$$

2|0

$$q_{enc} = \frac{\alpha r^3}{3} 2\pi L$$

$\Phi_E = \frac{1}{\varepsilon_0}(q_1 + q_2 + \dots + q_n)$ ∴ $(q_1+q_2+\dots+q_n)$ son las cargas encerradas

$$\vec{E}_e = \frac{\frac{\alpha r^3}{3} 2\pi L}{3\pi \varepsilon_0 L} = \frac{\frac{\alpha r^3}{3\varepsilon_0}}{3R} = \frac{\alpha r^3}{R\varepsilon_0} \quad r > R$$

$\vec{E} \parallel \hat{n}$ R cs

2) $\Phi = \frac{q_{cen}}{\varepsilon_0} = \oint \vec{E}\,\hat{n}\,dA$

$$\ast\ 2\Phi_E = 2\oint |\vec{E}|\,dA = 2E\oint dA = 2\frac{kq}{r^2}4\pi r^2$$

$$= \frac{2q}{4\pi\varepsilon_0 r^2} \cdot 4\pi r^2 = 2\frac{q}{\varepsilon_0} \quad (R\ es\ ex)$$

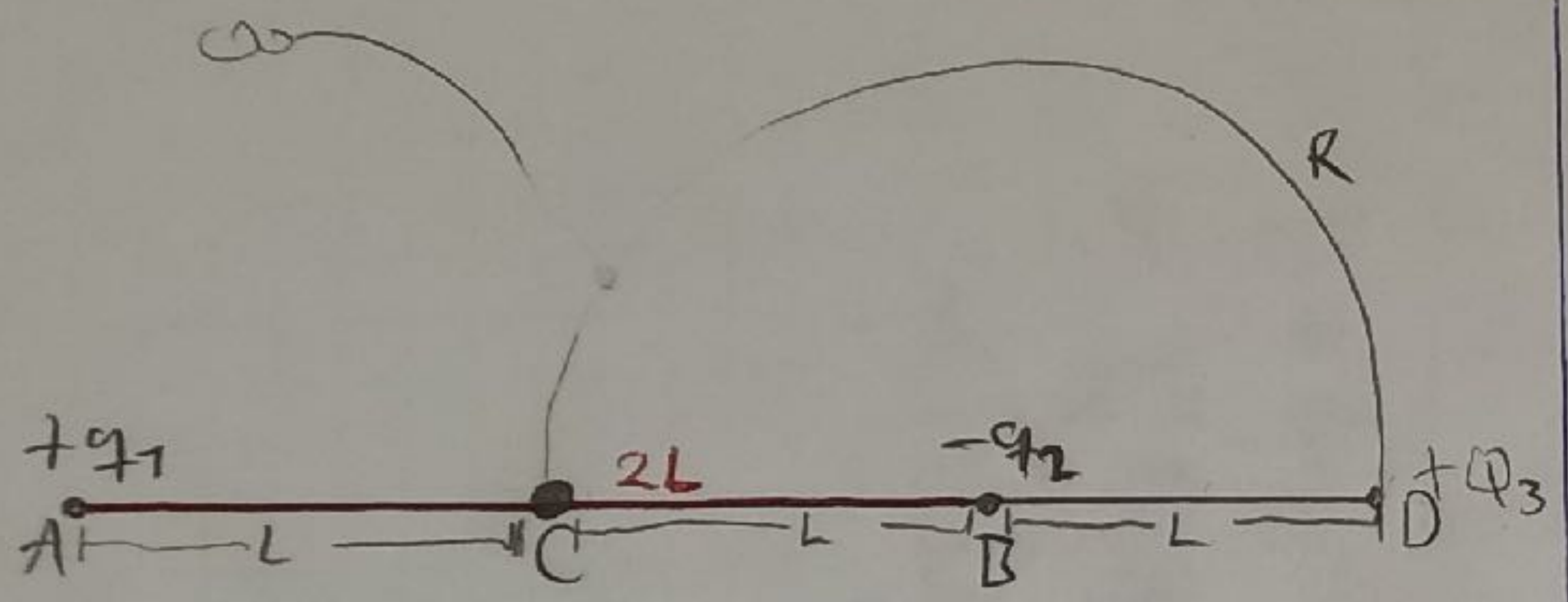
$$\ast\ \Phi_E = \oint |\vec{E}|\,dA = E\oint dA = \frac{kq}{r^2}4\pi r^2$$

$$= \frac{2q}{4\pi\varepsilon_0 r^2} \cdot 4\pi r^2 = \frac{q}{\varepsilon_0}$$

?

$1{,}6 \times 10^{-19}\, C \frac{J}{C} = 1\ eV$

1



$V = K \frac{q}{r}$

$r_1 = \frac{2L}{2} = L$

$W_{A \to B} = -q\,(V_B - V_A)$

$W_{C \to D} = -q\,(V_D - V_C)$

$V_{C1} = \frac{Kq_1}{L}$

$V_C = V_{C1} + V_{C2}$

$V_{C2} = \frac{K(-q_2)}{L} = -\frac{Kq_2}{L}$

$V_C = \frac{Kq_1}{L} + \frac{K(-q_2)}{}$

$V_D = V_{D1} + V_{D2}$

$V_{D1} = \frac{Kq_1}{2L+L} = \frac{Kq_1}{3L}$

E2AB

$V_{D2} = \frac{K(-q_2)}{L} = \frac{-Kq_2}{L}$

$V_D = \frac{Kq_1}{3L} - \frac{Kq_2}{L}$

$W_{C \to D} = -q\,(V_D - V_C)$

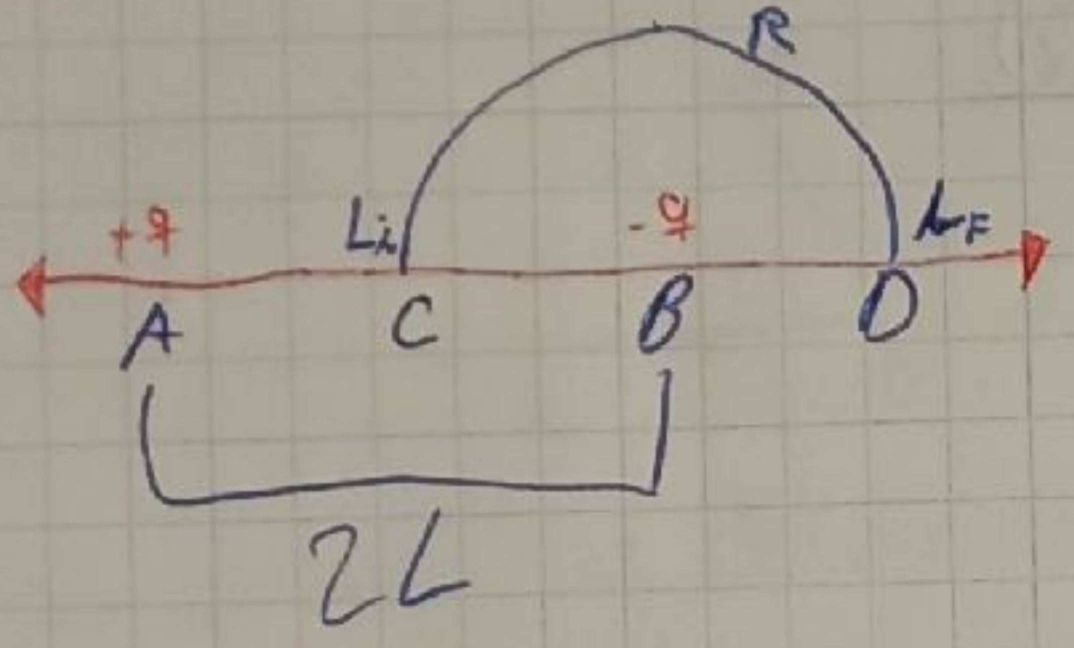
$W_{C \to D} = -Q\left(\frac{Kq_1}{3L} - \frac{Kq_2}{L} - \frac{K}{L}(q_1 - q_2)\right)$

2 La relación entre ~~ur~~ la diferencia de potencia

7,8 +

X

1.



$$W = -\Delta U = \int_C^D \vec{F}\cdot d\vec{l} = \int_C^D \vec{E}\cdot d\vec{l}$$

$$\Delta U = U_F - U_i$$

$$U_i = U_{i(q,q)} + U_{i(+q,+Q)} + U_{i(-q,+Q)}$$

$$U_i = k\frac{(+q)(-q)}{2l} + \frac{k(+q)(+Q)}{l} + \frac{k(-q)(+Q)}{l}$$

$$U_F = U_{F(+q,-q)} + U_{F(+q,+Q)} + U_{F(-q,+Q)}$$

$$U_F = k\frac{(+q)(-q)}{2l} + \frac{k(+q)(+Q)}{3l} + \frac{k(-q)(+Q)}{l}$$

1) Una carga puntual $q_1 = +6,0\,nC$ está situada en el origen. Una segunda carga puntual $q_2 = -5,0\,nC$ esta situada en $(5,0 ; 8,0 ; 0,0)$cm

¿Campo electrico en $A = (-4,0 ; 8,0 ; 0,0)$cm

$(0,05 ; 0,08 ; 0,00)$m $\quad (0, 0, 0)$m

$q_2 = -5,0\,nC = -5\times10^{-9}C \quad q_1 = +6,0\,nC = 6\times10^{-9}C$

$$\vec{E}_{q_1} = \left[9\times10^9\frac{Nm^2}{C^2}\right]\frac{(6\times10^{-9})C}{|r_1|^2}\hat{r}_1$$

$\vec{r_1} = (-4,0 ; 8,0 ; 0,0)$cm $= (-0,04 ; 0,08 ; 0,00)$m

$|r_1| = \sqrt{(-0,04)^2 + (0,08)^2} = \frac{\sqrt{5}}{25} = 0,08$m

$$\hat{r}_1 = \frac{(-0,04 ; 0,08 ; 0,00)}{0,08} = (-0,5 ; 1 ; 0)$$

reemplazando

$$\vec{E}_{q_1} = \left[9\times10^9\frac{Nm^2}{C^2}\right]\frac{(6\times10^{-9})C}{0,08^2\,m^2}\cdot(-0,50 ; 1,00 ; 0)$$

$$= (-4218,7 ; 8437,5 ; 0)\frac{N}{C}$$

$$\vec{E}_{q_2} = \left[9\times10^9\frac{Nm^2}{C^2}\right]\frac{(-5,0\times10^{-9})C}{|r_2|^2}\hat{r}_2$$

$\vec{r_2} = (-4,0 ; 8,0 ; 0,0)$cm $- (5,0 ; 8,0 ; 0,0)$
$= (-9,0 ; 0,0 ; 0,0)$cm $= (-0,09 ; 0 ; 0)$m

$|r_2| = \sqrt{(-0,09)^2} = 0,09$m

$$\vec{E}(r) = \frac{1}{4\pi\epsilon_0}\frac{q}{r^2}\hat{r}$$

Conceptos

Quiz

1. Una carga puntual $q_1 = +6{,}0$ nC está situada en el origen. Una segunda carga puntual $q_2 = -5{,}0$ nC está situada en $\langle 5{,}0; 8{,}0; 0{,}0\rangle$ cm ¿Cuál es el campo eléctrico total en el punto $A = \langle -4{,}0; 8{,}0; 0{,}0\rangle$ cm debido a q_1 y q_2? Si una carga $q_3 = -3{,}0$ nC se colocara en el lugar A ¿Cuál sería la fuerza sobre esta carga? [4 pts]

Datos

$$\vec{E}(r) = \frac{1}{4\pi\epsilon_0}\sum_{i=1}^{N}\frac{q_i}{r_i^2}\hat{r}_i$$

Resultado

Solución 1 Datos:

$$\begin{aligned}
q_1 &= +6{,}0\times 10^{-9}\ \mathrm{C} \Rightarrow \vec{r_1} = \langle 0{,}0; 0{,}0; 0{,}0\rangle\ \mathrm{m}\\
q_2 &= -5{,}0\times 10^{-9}\ \mathrm{C} \Rightarrow \vec{r_2} = \langle 0{,}05; 0{,}08; 0{,}0\rangle\ \mathrm{m}\\
A &\Rightarrow \langle -0{,}04; 0{,}08; 0{,}0\rangle\ \mathrm{m}
\end{aligned}$$

$$\begin{aligned}
\vec{r}_1 &= \langle -0{,}04; 0{,}08; 0\rangle\mathrm{m} - \langle 0,0,0\rangle\mathrm{m} = \langle -0{,}04; 0{,}08; 0\rangle\mathrm{m}\\
|\vec{r}_1| &= \sqrt{(-0{,}04)^2 + (0{,}08)^2} = 0{,}0894\ \mathrm{m}\\
\hat{r}_1 &= \frac{\vec{r}_1}{|\vec{r}_1|} = \frac{\langle -0{,}04; 0{,}08; 0\rangle\mathrm{m}}{(0{,}0894\ \mathrm{m})} = \langle -0{,}447; 0{,}894; 0\rangle\\
\vec{E}_1 &= \frac{1}{4\pi\varepsilon_0}\frac{q_1}{|\vec{r}_1|^2}\hat{r}_1 = \left(9\times 10^9\frac{\mathrm{Nm}^2}{\mathrm{C}^2}\right)\frac{(6{,}0\times 10^{-9}\mathrm{C})}{(0{,}0894\ \mathrm{m})^2}\langle -0{,}447; 0{,}894; 0\rangle\\
\vec{E}_1 &= \langle -3{,}02; 6{,}04; 0{,}0\rangle \times 10^3\ \mathrm{N/C}
\end{aligned}$$

$$\begin{aligned}
\vec{r}_2 &= \langle -0{,}04; 0{,}08; 0\rangle\mathrm{m} - \langle 0{,}05; 0{,}08; 0\rangle\mathrm{m} = \langle -0{,}09; 0; 0\rangle\mathrm{m}\\
|\vec{r}_2| &= \sqrt{(-0{,}09)^2} = 0{,}09\ \mathrm{m}\\
\hat{r}_2 &= \frac{\vec{r}_2}{|\vec{r}_2|} = \frac{\langle -0{,}09; 0; 0\rangle\mathrm{m}}{(0{,}09\ \mathrm{m})} = \langle -1,0,0\rangle\\
\vec{E}_2 &= \frac{1}{4\pi\varepsilon_0}\frac{q_2}{|\vec{r}_2|^2}\hat{r}_2 = \left(9\times 10^9\frac{\mathrm{Nm}^2}{\mathrm{C}^2}\right)\frac{(-5{,}0\times 10^{-9}\mathrm{C})}{(0{,}09\ \mathrm{m})^2}\langle -1,0,0\rangle\\
\vec{E}_2 &= \langle 5{,}56; 0; 0\rangle \times 10^3\ \mathrm{N/C}
\end{aligned}$$

$$\begin{aligned}
\vec{E}_{\mathrm{total}} &= \vec{E}_1 + \vec{E}_2\\
&= \langle -3{,}02; 6{,}04; 0\rangle\times 10^3\ \mathrm{N/C} + \langle 5{,}56; 0; 0\rangle\times 10^3\ \mathrm{N/C}\\
\vec{E}_{\mathrm{total}} &= \langle 2{,}54; 6{,}04; 0\rangle\times 10^3\ \mathrm{N/C}
\end{aligned}$$

La fuerza sobre q_3

$$\begin{aligned}
\vec{F}_3 &= q_3\vec{E}_{\mathrm{total}}\\
&= (-3{,}0\times 10^{-9}\mathrm{C})\,\langle 2{,}54; 6{,}04; 0\rangle\times 10^3\ \mathrm{N/C}\\
&= -\langle 7{,}62\times 10^{-6}; 1{,}81\times 10^{-5}; 0\rangle\ \mathrm{N}\\
&= -\langle 7{,}62; 18{,}1; 0\rangle\times 10^{-6}\ \mathrm{N}
\end{aligned}$$

$q_1 = 6.0\ nC \quad (0;0;0)\ cm$

$q_2 = -5.0\ nC \quad (5.0;8.0;0.0)\ cm$

Obs $(-4.0;8.0;0.0)$

$E_T = E_1 + E_2$

$E_1 = \frac{k q_1}{\vec{d}_{q0}^{\,2}} \hat{d}_{q0}$

$E_1 = 9\cdot10^9 \cdot \left(\frac{6\cdot10^{-9} C}{0.09^2\ m^2}\right) \hat{d}_{q0}$

$E_1 = 6666.7\ \frac{N}{C} \cdot \hat{d}_{q0}$

$E_1 = (-2933;5933;0.0)$

① Calculo respecto a d

$d_{q0} = 0 - q_1$ (ubicaciones)

$d_{q0} = (-0.04;0.08;0.0)$ m

$|d_{q0}| = \sqrt{(0.04)^2 + (0.08)^2}$

$= 0.09$

$\hat{d}_{q0} = (-0.44;0.89;0.0)$

② $E_2 = 9\cdot10^9 \cdot \left(\frac{5\cdot10^{-9} C}{0.09^2\ m^2}\right) \hat{d}_{q20}$

$E_2 = 5555.6\ \frac{N}{C} \cdot \hat{d}_{q20}$

$E_2 = (5555.6;0.0;0.0)$

① $d_{q20} = q_2 - 0$

$d_{q20} = (0.09;0.0;0.0)$ m

$|d_{q20}| = \sqrt{81}$

$= 9$ cms $\rightarrow 0.09$ m

$\hat{d}_{q20} = (1.0;0.0;0.0)$

$E_T = E_1 + E_2$

$E_T = (2622.6;5933;0.0)$

Quiz II

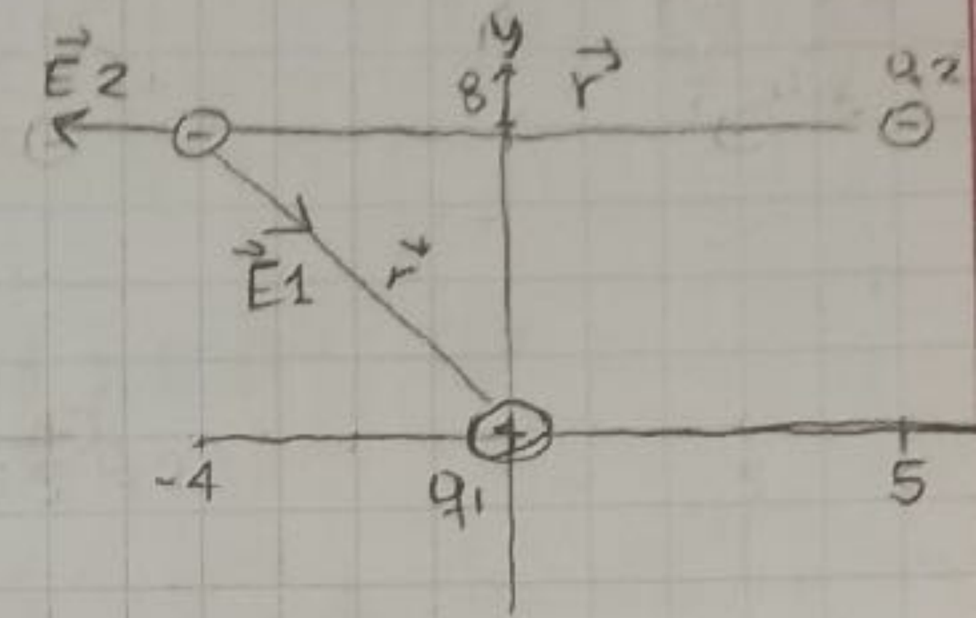
① $q_1 = +6\,nC \quad \langle 0,0,0\rangle$

$q_2 = -5\,nC \quad \langle 5,8,0\rangle$

$q_3 = -3\,nC$

$A = \langle -4,8,0\rangle$

Datos



$E_{13} = \frac{K q_1 q_3}{r^2}\hat{r}$

$\vec{r} = \langle 0,0,0\rangle - \langle -4,8,0\rangle$

$\vec{r} = \langle 4,-8,0\rangle$

$|r| = \sqrt{4^2+(-8)^2} = \cancel{4\sqrt{5}}$

$\hat{r} = \frac{\langle 4,-8,0\rangle}{\cancel{4\sqrt{5}}}$

$\vec{E} = \frac{9\times10^9\,(6\times10^6)\,(1{,}6\times10^{-19})\,(-3\times10^6)\,(1{,}6\times10^{-19})}{(4\sqrt{5})^2} \cdot \langle 4,-8,0\rangle$

$\vec{E}_0 = \langle -2{,}07\times10^{-16}\hat{\imath} + 4{,}14\times10^{-16}\hat{\jmath}\rangle$

$E_{23} = \frac{K q_2 q_3}{r^2}\hat{r}$

$\vec{r} = \langle 5,8,0\rangle - \langle -4,8,0\rangle$

$\vec{r} = \langle 9,0,0\rangle$

$|r| = \sqrt{9^2} = 9$

$\hat{r} = \frac{\langle 9,0,0\rangle}{9^2}$

$\vec{E} = \frac{9\times10^9\,(-5\times10^6)(1{,}6\times10^{-19})\,(-3\times10^6)\,(1{,}6\times10^{-19})}{9^2} \cdot \langle 9,0,0\rangle$

$\vec{E} = \langle 3{,}84\times10^{-16}\hat{\imath}\rangle$

```
import sympy
from sympy import *
from sympy.vector import CoordSys3D
N = CoordSys3D('N')
```

1. Una carga puntual q1 = +6,0 nC está situada en el origen. Una segunda carga puntual q2 = −5,0 nC está situada en ⟨5,0; 8,0; 0,0⟩ cm ¿Cuál es el campo electrico total en el punto A = ⟨−4,0; 8,0; 0,0⟩ cm debido a q1 y q2? Si una carga q3 = −3,0 nC se colocara en el lugar A ¿Cúal sería la fuerza sobre esta carga?

```
k=9*10**(9)
q1=6*10**(-9)
q2= -5*10**(-9)
q3= -3*10**(-9)
```

Datos

Calculos

1. Vector r13

```
r1 = (0*N.i +0*N.j + 0*N.k)*10**(-2)
r3 = (-4*N.i + 8*N.j + 0*N.k)*10**(-2)
```

```
r = r3-r1
r
```

$(-0.04)\hat{i}_N + (0.08)\hat{j}_N$

1.1 Módulo de r

```
r_mo=r.magnitude()
r_mo
```

0.0894427190999916

1.2 El vector unitario $\hat{r}$


```
r_u=r.normalize()
r_u
```

$(-0.447213595499958)\hat{i}_N + (0.894427190999916)\hat{j}_N$

1.3 Campo $\vec{E}1$

```
E1=(k*q1/r_mo**2)*r_u
E1
```

$(-3018.69176962472)\hat{i}_N + (6037.38353924943)\hat{j}_N$

```
E1.evalf(3)
```

$(-3.02 \cdot 10^{3})\hat{i}_N + (6.04 \cdot 10^{3})\hat{j}_N$

2. Vector r23

```
r2 = (5*N.i +8*N.j + 0*N.k)*10**(-2)
r3 = (-4*N.i + 8*N.j + 0*N.k)*10**(-2)
```

```
r = r3-r2
r
```

$(-0.09)\hat{i}_N$

2.1 Módulo de r

```
r_mo=r.magnitude()
r_mo
```

0.09

2.2 El vector unitario $\hat{r}$

```
r_u=r.normalize()
r_u
```

$(-1.0)\hat{i}_N$

2.3 Campo $\vec{E2}$

```
E2=(k*q2/r_mo**2)*r_u
E2
```

$(5555.55555555555)\,\hat{\mathbf{i}}_{\mathbf{N}}$

```
E2.evalf(3)
```

$(5.56 \cdot 10^{3})\,\hat{\mathbf{i}}_{\mathbf{N}}$

3. $\vec{E}$ total

```
Etotal=E1+E2
Etotal.evalf(3)
```

$(2.54 \cdot 10^{3})\,\hat{\mathbf{i}}_{\mathbf{N}} + (6.04 \cdot 10^{3})\,\hat{\mathbf{j}}_{\mathbf{N}}$

4. La fuerza sobre q3

```
F3=q3*Etotal
F3.evalf(3)
```

$(-7.61 \cdot 10^{-6})\,\hat{\mathbf{i}}_{\mathbf{N}} + (-1.81 \cdot 10^{-5})\,\hat{\mathbf{j}}_{\mathbf{N}}$

Haz doble clic (o ingresa) para editar

Solución 1 Datos:

$$\begin{aligned} q_1 &= +6{,}0 \times 10^{-9}\ \mathrm{C} \Rightarrow \vec{r_1} = \langle 0{,}0; 0{,}0; 0{,}0\rangle\ \mathrm{m} \\ q_2 &= -5{,}0 \times 10^{-9}\ \mathrm{C} \Rightarrow \vec{r_2} = \langle 0{,}05; 0{,}08; 0{,}0\rangle\ \mathrm{m} \\ A &\Rightarrow \langle -0{,}04; 0{,}08; 0{,}0\rangle\ \mathrm{m} \end{aligned}$$

$$\begin{aligned} \vec{r}_1 &= \langle -0{,}04; 0{,}08; 0\rangle\mathrm{m} - \langle 0, 0, 0\rangle\mathrm{m} = \langle -0{,}04; 0{,}08; 0\rangle\mathrm{m} \\ |\vec{r}_1| &= \sqrt{(-0{,}04)^2 + (0{,}08)^2} = 0{,}0894\ \mathrm{m} \\ \hat{r}_1 &= \frac{\vec{r}_1}{|\vec{r}_1|} = \frac{\langle -0{,}04; 0{,}08; 0\rangle\mathrm{m}}{(0{,}0894\ \mathrm{m})} = \langle -0{,}447; 0{,}894; 0\rangle \\ \vec{E}_1 &= \frac{1}{4\pi\varepsilon_0}\frac{q_1}{|\vec{r}_1|^2}\hat{r}_1 = \left(9 \times 10^9 \frac{\mathrm{Nm}^2}{\mathrm{C}^2}\right)\frac{(6{,}0 \times 10^{-9}\mathrm{C})}{(0{,}0894\ \mathrm{m})^2}\langle -0{,}447; 0{,}894; 0\rangle \\ \vec{E}_1 &= \langle -3{,}02; 6{,}04; 0{,}0\rangle \times 10^3\ \mathrm{N/C} \end{aligned}$$

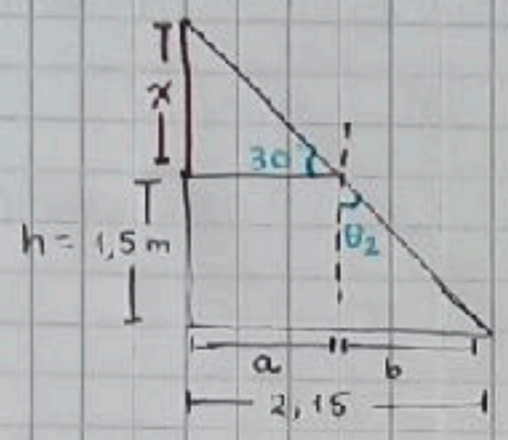
$$\begin{aligned} \vec{r}_2 &= \langle -0{,}04; 0{,}08; 0\rangle\mathrm{m} - \langle 0{,}05; 0{,}08; 0\rangle\mathrm{m} = \langle -0{,}09; 0; 0\rangle\mathrm{m} \\ |\vec{r}_2| &= \sqrt{(-0{,}09)^2} = 0{,}09\ \mathrm{m} \\ \hat{r}_2 &= \frac{\vec{r}_2}{|\vec{r}_2|} = \frac{\langle -0{,}09; 0; 0\rangle\mathrm{m}}{(0{,}09\ \mathrm{m})} = \langle -1, 0, 0\rangle \\ \vec{E}_2 &= \frac{1}{4\pi\varepsilon_0}\frac{q_2}{|\vec{r}_2|^2}\hat{r}_2 = \left(9 \times 10^9 \frac{\mathrm{Nm}^2}{\mathrm{C}^2}\right)\frac{(-5{,}0 \times 10^{-9}\mathrm{C})}{(0{,}09\ \mathrm{m})^2}\langle -1, 0, 0\rangle \\ \vec{E}_2 &= \langle 5{,}56; 0; 0\rangle \times 10^3\ \mathrm{N/C} \end{aligned}$$

$$\begin{aligned} \vec{E}_{\mathrm{total}} &= \vec{E}_1 + \vec{E}_2 \\ &= \langle -3{,}02; 6{,}04; 0\rangle \times 10^3\ \mathrm{N/C} + \langle 5{,}56; 0; 0\rangle \times 10^3\ \mathrm{N/C} \\ \vec{E}_{\mathrm{total}} &= \langle 2{,}54; 6{,}04; 0\rangle \times 10^3\ \mathrm{N/C} \end{aligned}$$

La fuerza sobre q_3

$$\begin{aligned} \vec{F}_3 &= q_3\vec{E}_{\mathrm{total}} \\ &= (-3{,}0 \times 10^{-9}\mathrm{C})\,\langle 2{,}54; 6{,}04; 0\rangle \times 10^3\ \mathrm{N/C} \\ &= -\langle 7{,}62 \times 10^{-6}; 1{,}81 \times 10^{-5}; 0\rangle\ \mathrm{N} \\ &= -\langle 7{,}62; 18{,}1; 0\rangle \times 10^{-6}\ \mathrm{N} \end{aligned}$$

1. Ley de Refracción



a) Inicialmente, evaluamos las condiciones del problema
Hay que tener en cuenta que la luz al cambiar de medio (pasa del aire a la piscina) presenta un suceso llamado refracción cuya fórmula de Snell sería
$n_1 \text{sen}(\theta_1) = n_2 \text{ sen}(\theta_2)$

b) Se deben tener en cuenta los datos del problema

$\theta_1 = 30°$ $\quad n_1 = 1 \rightarrow$ aire

$\theta_2 = ?$ $\quad n_2 = 4/3 \rightarrow$ agua $\quad x = ?$

c) Primero, para resolver el problema, se debe encontrar el ángulo θ_2

$$n_1 \text{ sen } \theta_1 = n_2 \text{ sen } \theta_2$$

despejamos θ_2,

$$\text{sen } \theta_2 = \frac{n_1 \cdot \text{sen}(\theta_1)}{n_2}$$

Reemplazamos valores y resolvemos.

$$\text{sen } \theta_2 = \frac{(1) \text{ sen}(30)}{4/3}$$

$$\theta_2 = \text{sen}^{-1}\left(\frac{3 \cdot \text{sen}(30)}{4}\right)$$

$$\theta_2 = 22{,}02° ; \text{ ángulo } \theta_2$$

d) Segundo, conociendo el ángulo θ_2 y la altura de la piscina, podemos calcular el lado b, por propiedades trigonométricas

$$\tan \theta_2 = \frac{b}{h}$$

Despejamos b.

$$b = (\tan \theta_2)(h)$$

Reemplazamos valores

$$b = \tan(22{,}02)\ (1{,}5)$$
$$b = 0{,}606 \text{ m}$$

0,5

e) Tercero, conociendo el lado b, podemos calcular a

$$a = 2{,}15 - b$$
$$a = 2{,}15 - 0{,}606$$
$$a = 1{,}544 \text{ m}$$

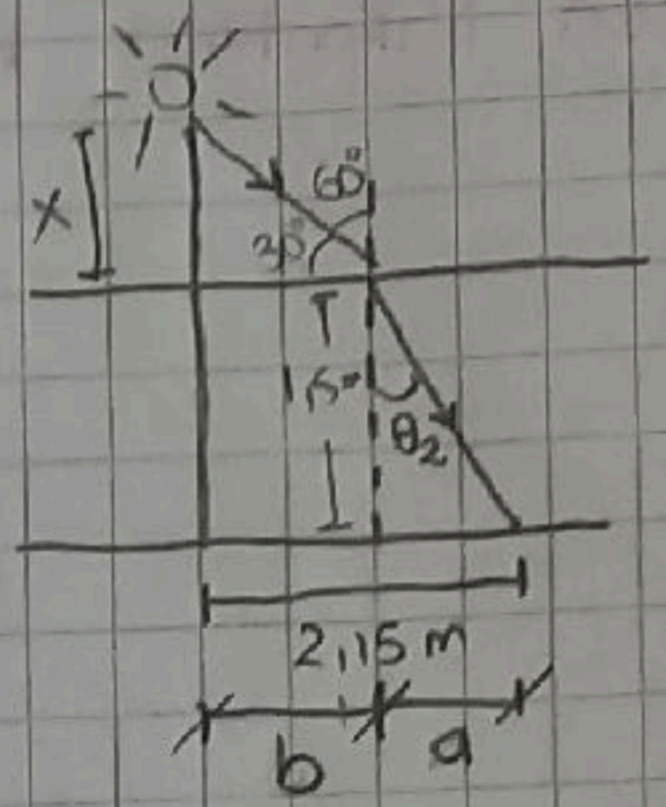
f) Por último, teniendo el lado a calculamos x

$$x = a \cdot \tan(30)$$
$$x = 1{,}544 \ \tan(30)$$
$$\boxed{x = 0{,}89 \text{ m}}$$ → altura del poste sobre la superficie del agua

---

$$n_1 \text{Sen}\theta_1 = n_2 \text{Sen}\theta_2$$

$n_1 = 1$
$n_2 = 4/3$
$\theta_1 = 60°$



$$\text{Sen}\theta_2 = \frac{n_1 \text{Sen}\theta_1}{n_2}$$

$$\theta_2 = \text{Sen}^{-1}\left(\frac{n_1 \text{Sen}\theta_1}{n_2}\right)$$

$$\theta_2 = \text{Sen}^{-1}\left(\frac{\text{Sen}(60)}{4/3}\right)$$

$$\theta_2 = 40{,}5°$$

$$\text{Tan}\,\theta_2 = \frac{a}{1{,}5}$$

$$a = 1{,}5 \text{ Tan}(40{,}5)$$
$$a = 1{,}28 \text{ [m]}$$

$$b = 2{,}15 - a$$
$$b = 2{,}15 - 1{,}28$$
$$b = 0{,}87 \text{ [m]}$$

2,0

$$\text{Tan}(30) = \frac{x}{b}$$

$$x = b\text{Tan}(30)$$
$$x = 0{,}87 \text{ Tan}(30)$$
$$x = 0{,}5 \text{ [m]}$$

Propuestas

- Como los programas de los cursos de Física no contemplan tiempo para actividades de este tipo, incluir estrategias de PC de manera “solapada” durante las actividades de los cursos a través de los Talleres.

- Crear un grupo de profesores sobre PC, para estudiar la factibilidad de aplicar el PC y crear estrategias para el desarrollo de herramientas computacionales en los cursos de Física General y sus laboratorios: análisis de datos, manipulación simbólica, cálculo numérico, modelado.

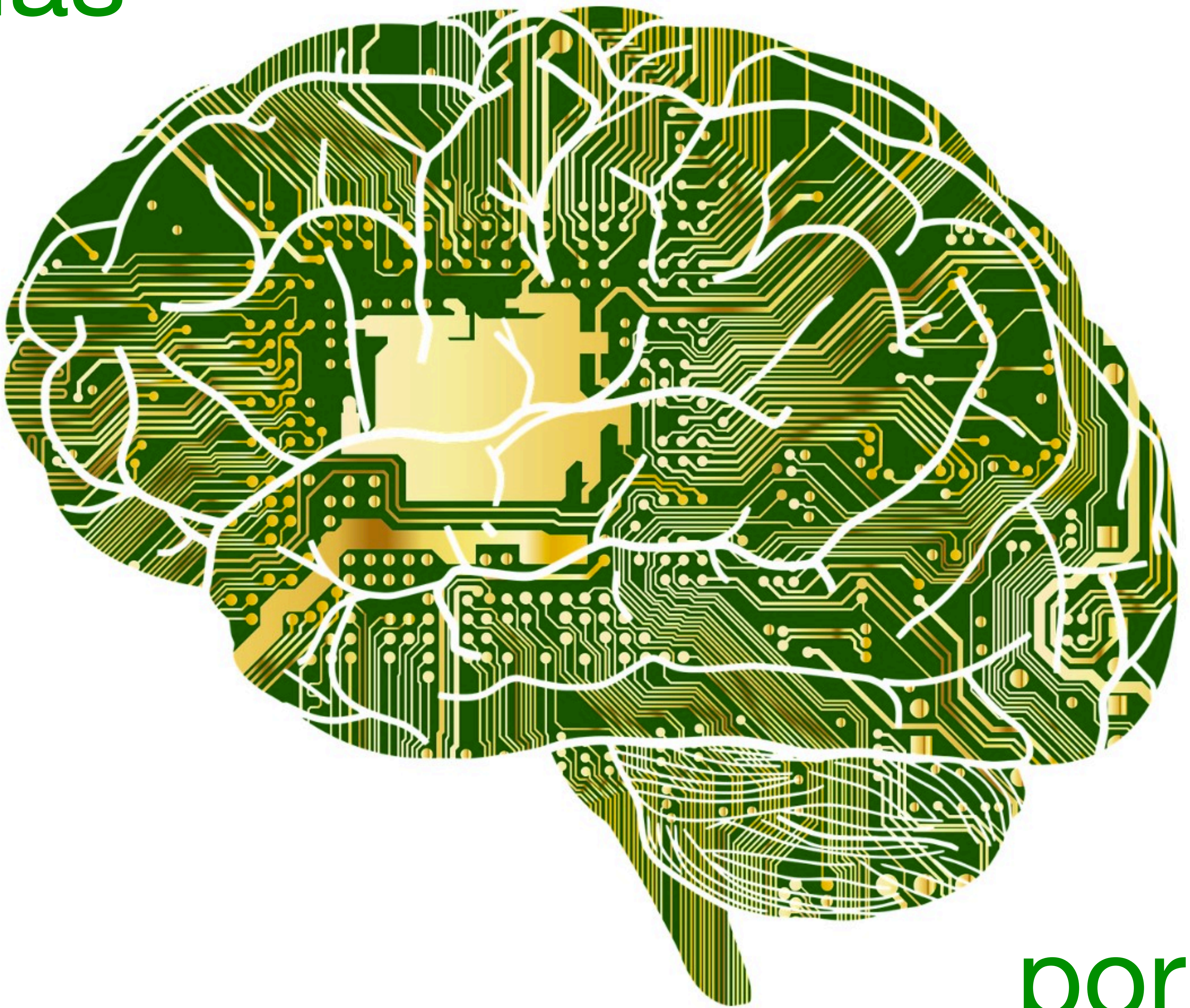
- Con ExperTIC reformular las estrategias de las CPS-L (¡La **IA** las resuelve todas!)

- Invitar a los demás profesores de la Escuela a introducir estrategias de PC.

- Introducir en los programas de Física I, II y III técnicas de PC de manera las tres materias queden conectadas en el uso de herramientas computacionales.

- Evaluar los efectos a mediano y largo plazo debido al uso de estas herramientas.

Gracias



por su atención

Restructuring the introductory electricity and magnetism course

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In the electricity and magnetism (E&M) segment of the traditional introductory calculus-based physics course, many new and increasingly abstract concepts, embodied in complex formal relations, are introduced at a rapid pace. As a result, many students find E&M significantly more difficult than classical mechanics. We describe a different intellectual structure for the E&M course that stresses conceptual coherence, connects the abstract field concept to concrete microscopic models of matter, and follows a clear story line, culminating in the classical model of the interaction of electromagnetic radiation and matter. This sequence has proven to be effective in teaching the basic concepts of E&M.
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I. WHY IS ELECTRICITY AND MAGNETISM DIFFICULT FOR STUDENTS?

Because electromagnetic interactions play a central role in determining the structure of the natural world and are the foundation of most current and emergent technology, a basic understanding of electricity and magnetism (E&M) is important. Traditionally, science and engineering students are introduced to E&M in the second half of the introductory calculus-based physics course, after they have completed an introduction to classical mechanics. However, even students who have done well in the first part of the course often find E&M to be difficult and confusing.

In E&M students encounter for the first time a level of abstraction and mathematical sophistication far beyond what they have experienced. In mechanics many situations involve familiar macroscopic objects: balls and sticks, cars and airplanes. At least some important concepts, such as velocity and force, are easily related to everyday experience. In E&M the student is quickly introduced to a world in which almost all of the quantities are invisible; they are either microscopic such as electrons or abstractions such as field, flux, and potential. Integral calculus becomes a central mathematical tool, and students are asked to apply it in unfamiliar ways, such as calculating the path integral or surface integral of a quantity expressed as a vector dot product. For the first time, it is necessary for students to think and visualize in three

sufficient practice to be able to apply these concepts reliably, or to discriminate them from each other. By the end of the course, even good students may have forgotten the expression for the electric field of a single point charge, because it has not been used for many weeks. Students who can reliably solve complex circuit problems often believe at the end of the course that electrons are used up in light bulbs or that the current produced by a battery is independent of the circuit it drives.[1,2] The rapid introduction of new concepts and escalation in complexity frequently confirms in students' minds the conviction that physics consists of a large number of disconnected formulas.

II. GOALS OF THE INTRODUCTORY PHYSICS COURSE

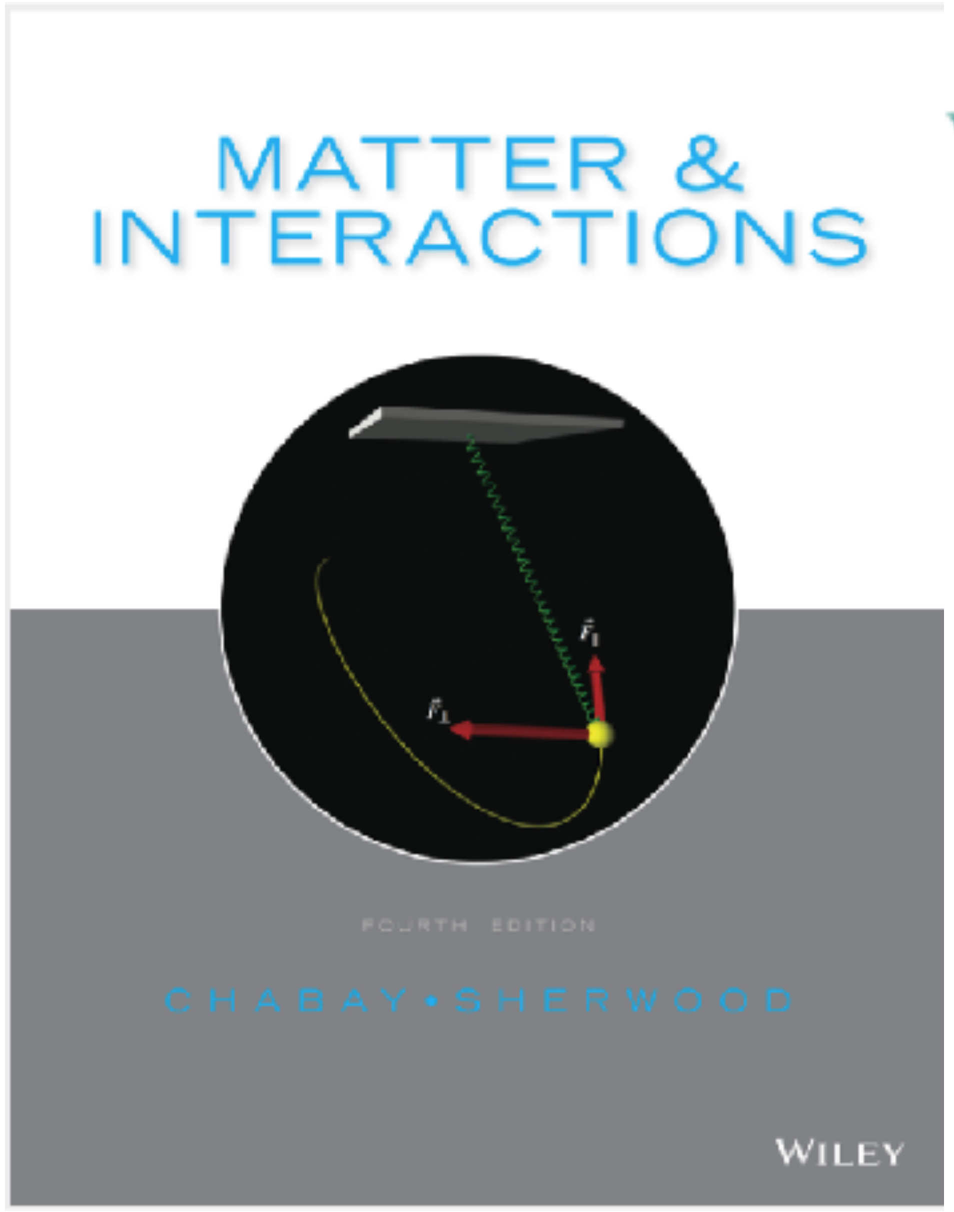
Some research and development in physics education has focused on remedying particular problems with the traditional sequence by giving students additional focused practice on selected concepts. However, without addressing the overarching issues of structure and coherence, it is difficult to do more than improve student performance on isolated tasks. We have chosen instead to reexamine the intellectual structure of the E&M curriculum to identify which concepts are centrally important, how these concepts are related, and how they can be introduced to students at the introductory level in a coherent, comprehensible sequence. To structure a sequence whose intellectual coherence is evident to students

III. CONTENT, SEQUENCE, AND EMPHASIS

The goals of the new sequence are to increase conceptual coherence, give students time to assimilate and master new concepts, add concreteness, and help students to develop microscopic models that facilitate reasoning about complex systems. The organization of topics is hierarchical, and the overarching theme of the entire sequence is the field concept. The sequence is organized into four large segments:

- Stationary charges
  - Electric field
  - A microscopic model of matter (conductors and insulators)
  - Effect of electric field on matter; the approach to equilibrium
  - Electric field of distributed charges
  - Electric energy and electric potential
- Moving charges
  - Magnetic field
  - Microscopic view of circuits (charge, field, energy, and the potential in dc and RC circuits)
  - Macroscopic view of circuits
  - Magnetic force; microscopic view of magnetic forces on currents
- Reasoning about patterns of field in space
  - Gauss's law and Ampere's law
- Time-varying fields and accelerated charges
  - Faraday's law
  - Maxwell's equations; electromagnetic radiation; classical interaction of light and matter
  - Physical optics; wave-particle duality

In the following, we discuss particular aspects of this sequence and indicate how these topics fit together into a coherent structure.



VOLUME I Modern Mechanics

VOLUME II Electric and Magnetic Interactions

The Supplements can be found at the web site, www.wiley.com/college/chabay

https://physics.sciences.ncsu.edu/people/rwchabay/

15.40 The calculated electric field
y observation locations.

which uses the index j, the next observation location is chosen. In the inner loop, which uses the index i, the field at the chosen observation location is calculated.

```
## calculate E at observation location
sf = 0.002  ## arrow scale factor
j = 0
## outer loop
while j < len(observation):
    rate(500)
    earrow = observation[j]
    ## add E of all slices for this obs. loc.
    i = 0
    E_net = vector(0,0,0)
    ## inner loop
    while i < N:
        r = earrow.pos - slices[i].pos
        rhat = r/mag(r)
        E = (oofpez * slices[i].q / mag(r)**2) * rhat
        E_net = E_net + E
        i = i + 1
        ## end of inner loop
    earrow.axis = sf*E_net
    j = j + 1
    ## end of outer loop
```

The result of this calculation is shown in Figure 15.40. In Problems P66–P67 you will add additional observation locations, or create a different pattern of observation locations.