Name: _____

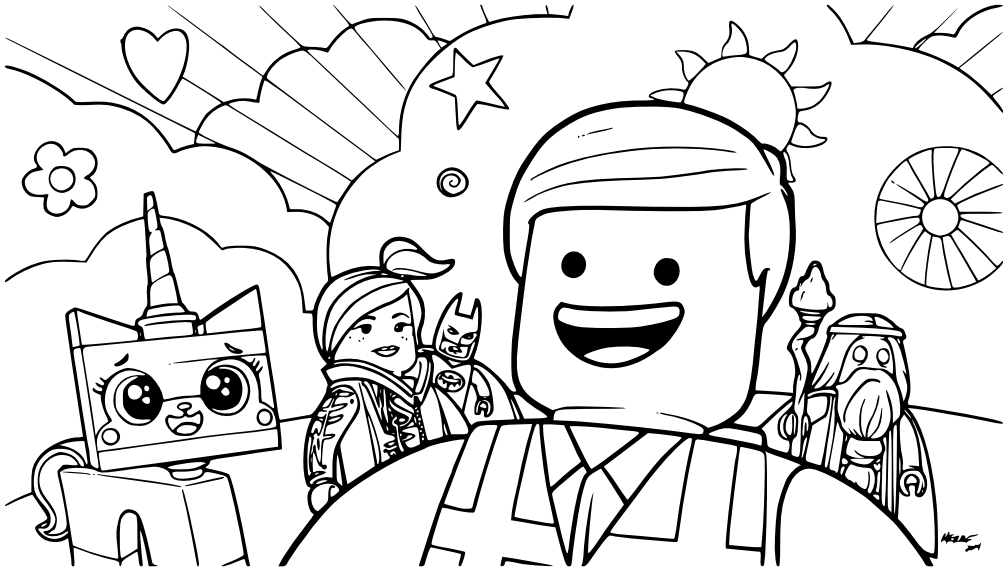
Test 3
The Building Blocks of Electromagnetism

Please answer the following questions in the space provided. Show *and explain* your work for full credit and any chance at partial credit! And remember: **Everything is awesome!**

Useful Constants
$g = 9.8\,\mathrm{m/s^2}$
$\epsilon_0 = 8.85 \times 10^{-12}\,\mathrm{C^2/Nm^2}$
$\frac{1}{4\pi\epsilon_0} = 9 \times 10^9\,\mathrm{Nm^2/C^2}$
$\frac{\mu_0}{4\pi} = 1 \times 10^{-7}\,\mathrm{T\,s/C}$
$c = 3 \times 10^8\,\mathrm{m/s}$

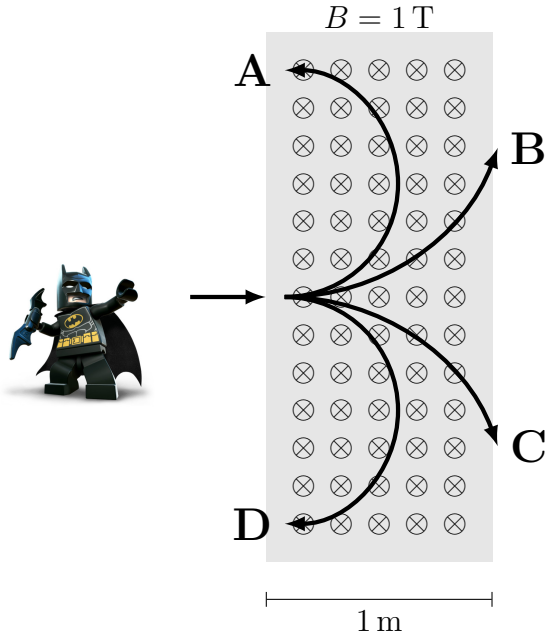
Old Useful Equations		
$F_c = \frac{mv^2}{r}$	$\Delta V = IR$	$A_{circle} = \pi r^2$

p	n	μ	m	c	k	M	G
10^{-12}	10^{-9}	10^{-6}	10^{-3}	10^{-2}	10^{3}	10^{6}	10^{9}



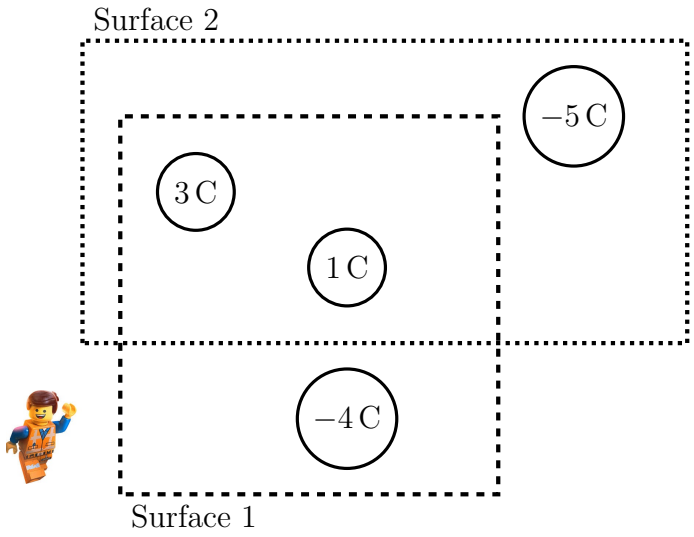
(2) 1. Lego Batman fires his electro-static grappler through a magnetic field at a speed of 2 m/s in the horizontal direction. If the grappler is comprised of a 10 g hook charged to −10 mC, in what location would it land on the far side of the 1 T magnetic field (or would it make it across)? Gravity is not affecting the grappler at all.

A. Location A
B. Location B
C. Location C
D. Location D



(2) 2. Emmet has constructed the below 2D Gaussian surfaces around the shown charges. Which of the following statements is true?

A. The electric field is constant around Surface 2.
B. The electric field is zero around Surface 1.
C. The same amount of electric field enters Surface 2 as leaves Surface 2.
D. The same amount of electric field enters Surface 1 as leaves Surface 1.



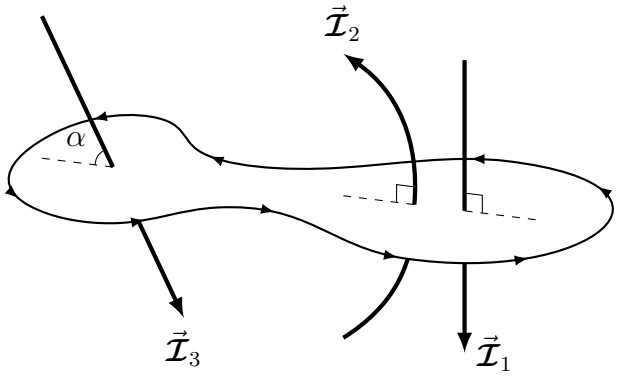
(2) 3. Lego Gandalf has conjured up a magical loop in the air which is pierced by several different constant currents. What can he conclude about the total integral of $\vec{\mathbf{B}} \cdot d\vec{\boldsymbol{\ell}}$ about the loop in the direction shown?

A. $\mu_0 (\mathcal{I}_1 - \mathcal{I}_2 + \mathcal{I}_3)$

B. $\mu_0 (-\mathcal{I}_1 + \mathcal{I}_2 - \mathcal{I}_3)$

C. $\mu_0 (\mathcal{I}_1 - \mathcal{I}_2 + \mathcal{I}_3 \cos\alpha)$

D. $\mu_0 (-\mathcal{I}_1 + \mathcal{I}_2 - \mathcal{I}_3 \sin\alpha)$



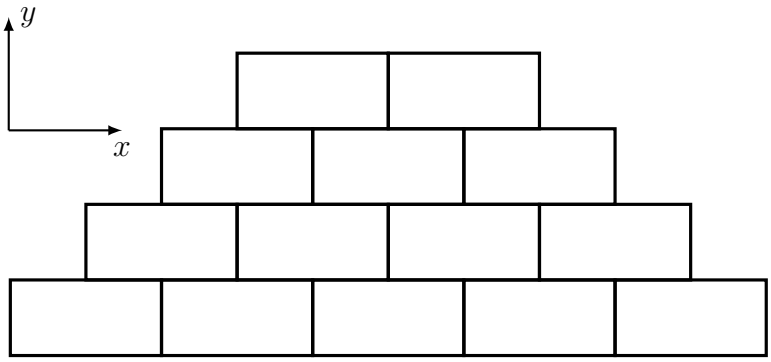
4. Unikitty fires a rainbow from her horn with a wavelength of 550 nm and a peak electric field equal to

$$\vec{\mathbf{E}} = (100\,\mathrm{V/m})\,\hat{\mathbf{z}}$$

(2) (a) In what direction is the corresponding peak magnetic field pointing if the wave is traveling in the negative $\hat{\mathbf{y}}$ direction? Explain your conclusion.

(4) (b) How much energy per second does Unikitty's rainbow impart to a 10 cm by 10 cm patch of Legos?

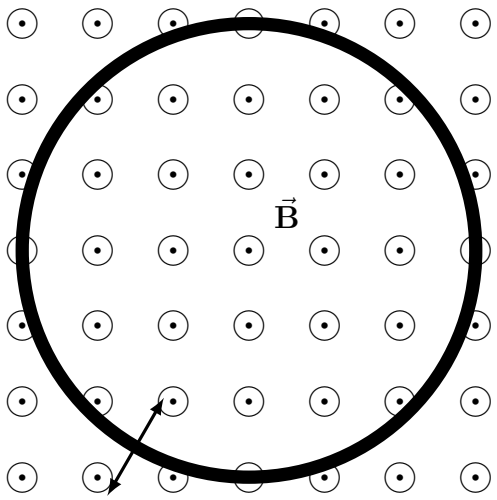
(4) 5. Wyldstyle has constructed a small wall out of Lego bricks. Each brick measures 1 cm tall and 2 cm wide. If there is an electric field present, $\vec{\mathbf{E}} = \langle 4, 2, -5 \rangle$ V/m, what is the total flux through the wall? Is it pointing out of the wall or into the wall as drawn?



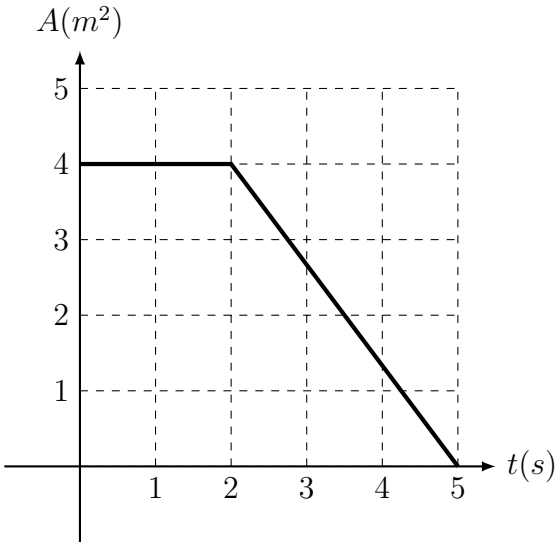
(8) 6. Lord/President Business needs to induce a current in a single, variable area loop in order to power his latest superweapon. The area of the loop changes with time according to the plot below. If the loop is placed in a constant 10 T magnetic field, what is the potential difference around the loop *and* in what direction is any induced current flowing at:

(a) $t = 1\,\mathrm{s}$

(b) $t = 3\,\mathrm{s}$



Variable size loop



(3 (bonus)) 7. Vitruvius has found a sphere of radius 1 m which has a total charge of 1 mC distributed uniformly throughout. Vitruvius is curious what the electric field is 25 cm from the center of the sphere (so at a point inside the sphere). Use Gauss's law to find the electric field at this point.

Now everything is truly awesome!! Have a good weekend!