# 1 Rotational EMF Project Log Book

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## 2.1 Theory

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# 3 Experiments

## 3.1 Day 1 (03/01/21):

We came to the lab and started to identify the equipment. We wanted to devise a way to make measurements of the probes only to realize such a contraption was already made. Upon investigation, we realized the measurements were not correct so we measured the distances using a ruler and taped it to the system.

We realized to answer the first 4 questions we needed to conduct an experiment where we keep $B, \omega$ the same while changing the radial position of the probe, $r$ and record the associated emf, $\epsilon$.

We were trying to understand each component of the apparatus. We realized that there is no stroboscope.

We needed to have a constant $B$ field. For that we needed to have a method to measure the $B$ of the two Helmholtz coil system at the plane of the circular disc. We derived the $B$ to be as follows:

$$B = \frac{8\mu_0 N I}{5\sqrt{5}R}$$

From the equation, we see that for a fixed $I$, $B$ would be constant for a given distance $R$.

Since we were missing the stroboscope, we found alternative sources. Sam found an app - Video Tachometer. We used that to find the frequency of rotation of the disc which the app recorded to be $56.03Hz$ which is well within the guidelines of the manual.

Since the method for getting this measurement was kind of clunky. We added a small mark on the disc to make sure we actually record the accurate value. We get $\omega = 54.43hz$.

We plan on changing the probe distance from $0.5$ to $4.5$ cm in increments of $0.5$ cm. We keep the current value, ($I = 5.01A$) to be the same and calculate the $B$.

We record the voltage value after 10 seconds for each trial to limit the effects of varying rotation speed of the speed and fluctuating voltage.

In [4]:
```
def getB(I,r): #mT
    r = r*0.01
    u0 = 1.25663706*(10**-6)
    N = 294
    B = (8/(5*np.sqrt(5)))*((u0*I*N)/r)
    return B*1000

def uplot(xv,yv,xerr,yerr,figNo,xlab="",ylab="",title="",caption=""):
    plt.title(title)
    plt.errorbar(xv, yv, xerr=xerr, yerr=yerr, ms=20, mew=4)
    plt.xlabel(xlab)
    plt.ylabel(ylab)
    plt.grid()
    getCaption(figNo, caption)
    plt.show()
```

In [5]:
```
r =[0.5,1,1.5,2,2.5,3,3.5,4,4.5] # cm
r2 = np.array(r)**2 # cm^2
```

In [7]:
```
I, w = 5.01, 54.43
#B = getB(4.)
emf = [0.6,0.8,1.1,1.5,2,2.4,2.9,3.5,4.0] #mV
```

We observe that the disc is uneven making the probes contact on the surface not uniform. This may affect the rotation speed of the disc.

In [10]:
```
plt.title("EMF vs R")
plt.errorbar(r, emf, xerr=0.1, yerr=0.1, ms=20, mew=4)
plt.xlabel("R (cm)")
plt.ylabel("EMF (mV)")
plt.grid()
getCaption(1, r"Relationship between EMF and Probe Seperation Distance")
plt.show()
```

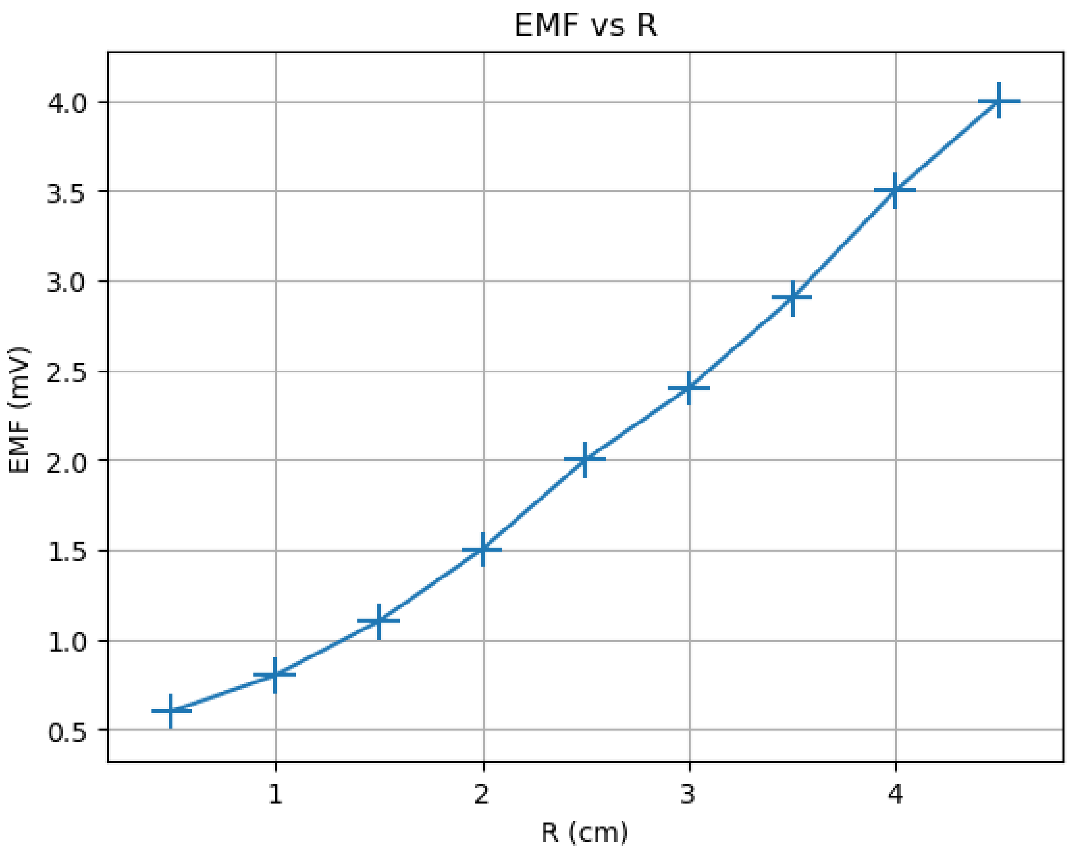


Fig 1: Relationship between EMF and Probe Seperation Distance

The uncertainty in the $R$ is calculated using error propagation.

In [19]:
```
from uncertainties import ufloat

def uncertainties_product(a,b,da,db):
    return np.sqrt(np.square(np.array(a))*db**2 + np.square(np.array(b))*da

def uncertainties_Bfield(a,b,da,db,B):
    return B*(np.sqrt(da**2/np.square(np.array(a)) + db**2/np.square(np.arr
```

In [18]:
```
plt.title(r"EMF vs $R^2$")
plt.errorbar(r2, emf, xerr=uncertainties_product(r,r,0.1,0.1), yerr=0.1, ms
plt.xlabel(r"$R^2 (cm^2)$")
plt.ylabel("EMF (mV)")
getCaption(2, r"Relationship between EMF and Probe Seperation Distance Squa
plt.show()
```

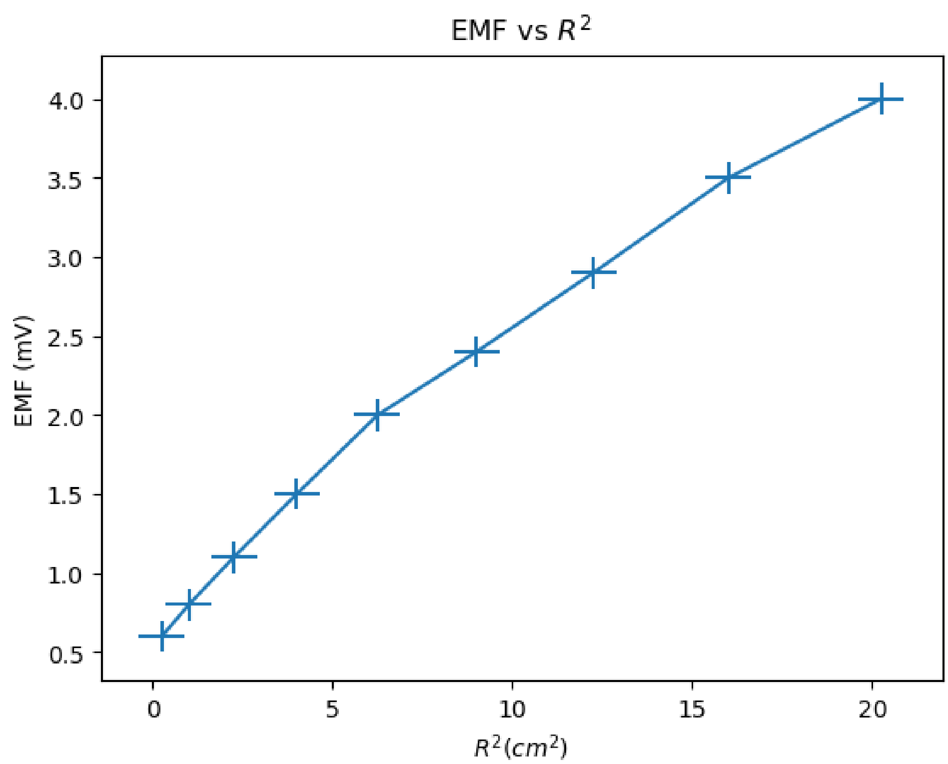


Fig 2: Relationship between EMF and Probe Seperation Distance Squared

Now, we fix the position and $\omega$ and vary the current in the domain $[1, 10]$ A increasing by $1A$ with seperation being $4.5cm$.

In [13]:
```
r = 4.5 #cm
I_exp2 = [1.04,2.02,3.01,4.01,5.03,6.03,7.06,8.00] #A
emf_exp2 = [0.5,1.3,2.2,3.1,3.9,4.8,5.6,6.4] #mV
B_exp2 = [getB(I,r) for I in I_exp2] #mT
```

Change uncertainty for B.

```
In [20]: uplot(B_exp2, emf_exp2, uncertainties_Bfield(r*0.01,I_exp2,0.1*0.01,0.1,B_e
```

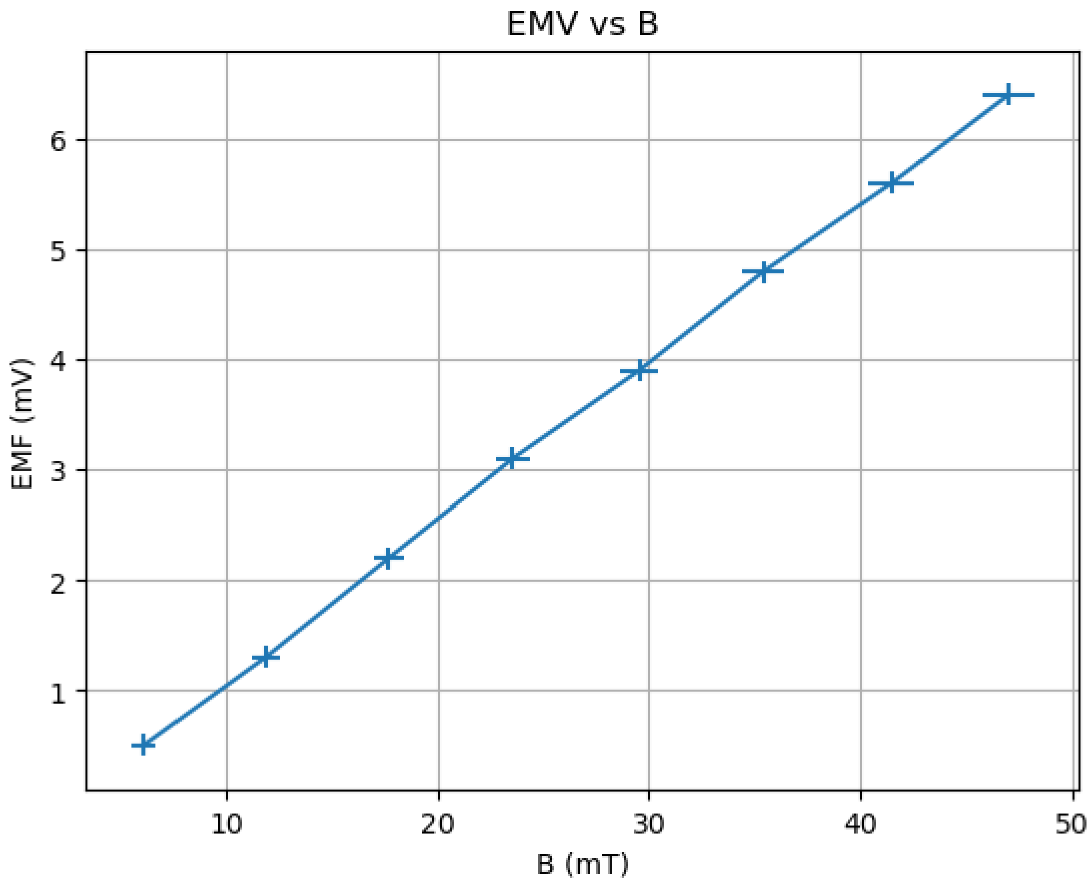


Fig 3: Relationship between B and EMF

For part 3, since we cannot change the frequency of the copper disc we were asked by Imtiaz to derive the equations instead.

### 3.2 Day 2 (03/03/21):

## 4 Conclusion & Summary

## 5 Project Questions:

1. Plot V vs I, as shown above. Discuss your circuit to collect data. Calculate maximum and average power output. Make sure to include uncertainties, P ± ΔP .

**Solution:**

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2. Is a solar panel a current source, voltage source, or both? Include a plot or diagram to explain your reasoning.

**Solution:**

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3. What is the efficiency of your solar panel? You can easily find out what the irradiance at the moment you are making your measurements outside. See West Texas Mesonet data for all kinds of weather related minute by minute information. For example, see [http://rain.ttu.edu/tech/1-output/mesonet.php (http://rain.ttu.edu/tech/1-output/mesonet.php)](http://rain.ttu.edu/tech/1-output/mesonet.php).

**Solution:**

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4. How much power is generated per solar panel?

**Solution:**

The power generated by *our particular solar panel* was roughly $45W$. (calculation done in section 3)

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5. Explain the p-n junction.

**Solution:**

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6. Explain the differences between the photovoltaic effect and the photoelectric effect. Why is this an important idea to understand?

**Solution:**

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7. Why are solar panels typically made of silicon? Could we use some other material?

**Solution:**

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8. Based on your measurements, estimate how many solar panels you would need to power a typical house. Make an estimate of the cost. Argue if it makes sense to go solar or not in Lubbock.

**Solution:**

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