Lab3 Problem 1: ELECTRICAL AND MECHANICAL ENERGY

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Abstract

The voltage of a stable battery which is used to charge the capacitors was determined. The capacitances of three different capacitors was determined. The relationship between energy stored in capacitor and the voltage and capacitance of capacitor is determined. The energy stored in fully charged capacitors under predetermined voltage was calculated out. The theoretical distance the mass was lifted by transferred energy from capacitors with 100% efficiency was calculated out.

Introduction

To design a lightweight power source for deploying the solar panels , understanding the use and real effect of power source is very essential. So the aim of this experiment is to understand and determine how the energy transferred to a device from a capacitor change with the change of the capacitor's capacitance. The initial voltage of capacitors with different capacitance is same. By measuring the lifted distance and calculating the improved mechanical energy of the mass powered by capacitor with different capacitors, the aim of experiment could be achieved.

Prediction

Mathematically the energy stored in the capacitor is linear to capacitor's capacitance and the square of voltage. $\boldsymbol{E_{capcitor} = \frac{1}{2}CV^2}$.C is the capacitance of the capacitor and V is the capacitor's initial voltage.

The energy transferred from capacitor to the mass could be determined by calculating the improved mechanical energy of mass. When mass was lifted to the highest point by capacitor with velocity equal to zero, the gravity potential energy of the mass is just its improved mechanical energy. $\boldsymbol{E_{improved} = mgh}$. In this equation h is the highest lifted distance of mass and g is the gravity constant. If the efficiency of transferred energy from capacitor is e. We conclude that

$$\boldsymbol{E_{capcitor} = \frac{1}{2}CV^2 = E_{improved} = mgh \;\; h = \frac{eCV^2}{2mg}}.$$

We predicted that when the initial voltage of capacitor and the weight of mass is stable, the lifted distance of the mass is linear to the capacitance of capacitor.

Procedure

We use three different capacitors to power the mass as power source. The marked capacitance of three capacitors are 0.11F, 0.21 F and 0.068F respectively. We charged capacitor to the 5V as its initial voltage. Then we connect mass which is 50g to the motor with the string making the mass lifted by the string at the point which is almost touch the ground. When the motor is correctly connected to the terminal of the capacitor the mass is lifted and we measured its highest lifted distance. We fully charge the capacitor again and repeat this process. Three different capacitors were respectively done so for five time.

Capacitance	m	Voltage	Distance	$E_{improved}$	E_{stored}
0.11F	50g	5V	0.46	0.2254	1.375
0.11F	50g	5V	0.44	0.2156	1.375
0.11F	50g	5V	0.45	0.2205	1.375
0.11F	50g	5V	0.445	0.2180	1.375
0.11F	50g	5V	0.43	0.2107	1.375

Capacitance	m	Voltage	Distance	$E_{improved}$	E_{stored}
0.21F	50g	5V	0.52	0.2548	2.625
0.21F	50g	5V	0.56	0.2744	2.625
0.21F	50g	5V	0.54	0.2646	2.625
0.21F	50g	5V	0.55	0.2695	2.625
0.21F	50g	5V	0.58	0.2842	2.625

Capacitance	m	Voltage	Distance	$E_{improved}$	E_{stored}
0.068F	50g	5V	0.438	0.2146	0.85
0.068F	50g	5V	0.450	0.2205	0.85
0.068F	50g	5V	0.462	0.2264	0.85
0.068F	50g	5V	0.438	0.2146	0.85
0.068F	50g	5V	0.450	0.2205	0.85

Table1,Table2,Table3: These three table are all built with six sets: The capacitance of capacitor, the mass of the particle which is lifted, the initial voltage of the capacitor, the highest lifted distance of the mass, the improved mechanical energy of the mass and the initially stored energy in the capacitor.

Analysis:

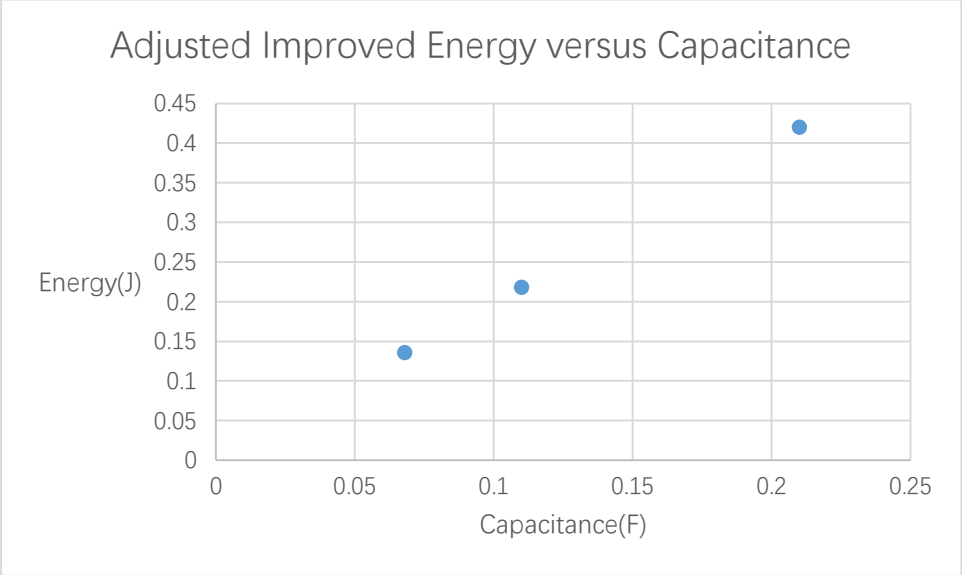
From three tables below we discovered that the efficiency of transferring energy for three capacitors are different. To achieve our aim of the experiment and derive the conclusion, we calculated out the average improved energy for mass powered by three capacitors respectively. The efficiency of transferring is $e = \frac{average(E_{improved})}{Estored}$. We adjust the average improved energy of mass powered by last two capacitor as that

$E_{adj} = \frac{average(E_{improved}) \times e1}{e2}$ or $E_{adj} = \frac{average(E_{improved}) \times e1}{e3}$

The e1,e1 and e3 of the equation below is respectively the efficiency of transferring energy towards three different capacitors.

	Average($E_{improved}$)	E_{stored}	Efficiency	E_{adj}
0.11F	0.2180	1.375	15.9%	0.2180
0.21F	0.2695	2.625	10.2%	0.4201
0.068F	0.2193	0.85	25.7%	0.1356

Table 4: The adjusted average improved energy for the mass powered by the three capacitors separately is shown by this table.



Because we have adjusted the improved energy by relative efficiency,under the stable efficiency e1, the figure below clearly presented that the improved energy is closely linear to the capacitance as the equation $mgh = \frac{1}{2}e_1CV^2$

To determine the uncertainty of this experiment, I calculated the standard deviation of the measured distance to prove the accuracy of this experiment.

Capacitor	Average(height)	height1	height2	height3	height4	height5	Standard deviation
0.11F	0.445	0.46	0.44	0.45	0.445	0.43	0.10
0.21F	0.55	0.52	0.56	0.54	0.55	0.58	0.02
0.68F	0.448	0.438	0.450	0.462	0.438	0.450	0.01

Table: This table shows the standard deviation of measured lifted distance powered by three capacitors. For the biggest standard deviation, the uncertainties for measured distance is only ± 0.10 cm. It is reasonable enough that differences between average distance and measured distance are in the range of random uncertainties.

Conclusion:

The lifted distance of the mass powered by capacitor is determined by the capacitance of the capacitor while keeping the other variables a constant

value and the relationship is closely matched the predicted equation: $\boldsymbol{h = \frac{eCV^2}{2mg}}$. The lifted height will linearly increase with the increase of the capacitor's capacitance.