

Friction, Work, and Energy on an Inclined Plane

-ACTIVITY 3 & 4

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Abstract

In this experiment we worked with an incline surface to study the sliding friction. We used this information to later study Work and energy. In activity 3 we used to compare the coefficient value μ of kinetic friction to the predicted value that was given in the index. For this part of experimented, we concluded that the predicted value and approximated value were within the margin. This was given μ_{ave} , 0.577, compared to the 0.2-0.6 predicted values. For activity 4, we used the data from activity to study the transfer of mechanical energy. We studied the loss of energy due to the non-conservative forces. We concluded that work of friction is accountable for the loss of energy as our discrepancy ($E_f - E_i - Wf$) for all distance values approximately equaled zero. Thus, the loss of energy due to friction was cause caused by the Work done by friction itself.

Theory

Kinetic energy is the result of an object in contact with a surface that is not static. According to Newtons 3rd law, for every action there is an equal and opposite reaction. This means that external force that is exerting on the object, when static, is equal to the Friction force f_s which has a value $\mu_s \cdot (f_s = \mu_s N)$. N is the value of the normal force that is given by the Newton's second law $F = ma$. If the object comes into motion (sliding), then the coefficient value is smaller that value μ_s . This gives us the value μ of kinetic friction. ($f = \mu N$).

Work done by gravity is (GPE) is given by mgh . In which m is equal to the mass of the wooden block. g is given by the absolute value of the acceleration of gravity= 9.8m/s^2 . h is given by the height of the distance between the beginning and ending positions.

Work done by friction (Wf) is given by $-fd * \cos(\Theta)$. In were f is the kinetic friction and the angle(Θ) is the tracks inclination. d is the distance the block travelled.

$$F = ma$$

$$Wf = -fd * \cos(\Theta)$$

$$f = \mu N$$

$$\mu = \tan(\Theta) - v^2 / (2gd\cos(\Theta))$$

$$r = \frac{L}{N}$$

$$E_f - E_i = Wf$$

$$KE = \frac{1}{2}mv^2$$

$$GPE = mgh$$

Procedure

- Equipment list (Physics Lab Note book, pg 70)
 - Track
 - Wooden block
 - Protractor
 - Pasco Photogate
 - Pasco Photogate instrument box
 - Vernier Caliper
 - Flag (Post it)
- 1st
 - On the inclined track we placed our Pasco Photogate at a distance that we called the origin. Then using the Pasco Photogate Instrument Box, we installed and configured the Photogate through the laptop.
- 2nd
 - My lab partners and I, using a protector, measured the angle of which the track was positioned too. This angle θ was approximated and confirmed by using the equation $\tan^{-1}(\frac{\text{height}}{\text{width}})$. According to this equation our approximations were close enough to conclude them true.
- 3rd
 - Using the Vernier caliper, we measured that width of the flag. This measurement L was going to be the object detected by the Pasco Photogate that calculates how long it takes it to cross the sensor. This flag was mounted at the edge of the wooden block.
- 4th
 - The wooden block was placed at 20cm away from the origin. The distance was referred to as distance d . The origin was considered location of where the Pasco Photogate sensor was placed. We carefully gave the block a slight push, while someone started the timer, we observed how long it took to cross the finish line. We incremented the distance away from the origin by 20cm 3 more times, and for each new distance and repeated the same thing. We took 5 data sets for each distance d .

Sample calculations for activity 4.

$(4 \text{ cm} \rightarrow 0.04 \text{ m})$

$20 \text{ cm} \times \frac{1 \text{ cm}}{100 \text{ m}} = 0.2 \text{ m}$

$t_{\text{ave}} = \frac{0.18 + 0.16 + 0.16 + 0.16 + 0.16}{5} = 0.164 \text{ s}$

$KE_i = \frac{1}{2} m v_i^2 = \frac{1}{2} m (0)^2 = 0 \text{ J}$

$GPE_i = mgh = 0.226 \text{ kg} \times 9.8 \frac{\text{m}}{\text{s}^2} \times 0.16 \text{ m} = 0.354 \text{ J}$

$v = \frac{L}{\Delta t} = \frac{0.007642 \text{ m}}{0.164 \text{ s}} = 0.04659 \text{ m/s}$

~~Mass~~

0.000245 J

$KE_f = \frac{1}{2} m v^2 = 0.5 \times 0.226 \text{ kg} \times 0.04659^2 \text{ m/s}^2$

$GPE_f = mgh = 0.226 \text{ kg} \times 9.8 \times 0.06 \text{ m} = 0.1326 \text{ J}$

$E_f - E_i = (KE_f + GPE_f) - (KE_i + GPE_i)$

$(0.00024 \text{ J} + 0.132 \text{ J}) - (0 \text{ J} + 0.354 \text{ J}) = -0.221 \text{ J}$

$E_f - E_i = W_f$

$-0.221 \text{ J} = M \times m \times g \times d \cos(30) \quad 0.000145$

$-0.221 \text{ J} = 0.577 \times 0.226 \text{ kg} \times 9.8 \frac{\text{m}}{\text{s}^2} \times 0.2 \text{ m} \cos(30) = 0$

Sample Calculations for Table Activity 3

$$d_{cm} = d_m$$

$$\frac{20 \text{ cm}}{100 \text{ m}} \times \frac{1 \text{ m}}{100 \text{ m}} = \boxed{0.2 \text{ m}}$$

$$\theta_{deg} \rightarrow \theta_{rad.}$$

$$30^\circ \text{deg} \times \frac{180 \text{ deg}}{\pi \text{ rad}} = \boxed{0.523 \text{ rad.}}$$

$$t_{ave} = \frac{0.18 + 0.16 + 0.16 + 0.16 + 0.16}{5} = \boxed{0.164 \text{ s}}$$

$$\mu = \tan(\theta) - \frac{v^2}{2gd \cos \theta} = 0.577 - \frac{0.04654}{2 \cdot 9.8 \cdot 0.2 \cos 30} = 0.576$$

$\boxed{0.6}$

$$\tan(30)$$

$$v = \frac{L}{\Delta t} = \frac{0.067642 \text{ m}}{0.164 \text{ s}} = \boxed{0.04654 \text{ m/s}}$$

$$F = \mu mg \cos(30)$$

$$0.6 \cdot 0.226 \text{ kg} \cdot 9.8 \text{ m/s}^2 \cdot \cos 30 = \boxed{1.1 \text{ N}}$$

Question 5: Does your result agree with the margin of error with the expected value and with the value obtained in activity 2?

My resultant value μ does agree with the expected value provided, which is 0.2-0.6. My value obtained from activity 2, 0.577, which is just shy from the expected value 0.6.

Question 6: Do you expect the force of friction to vary with the distance traveled by the block or will it stay the same?

I did not expect the force of friction to vary according to the distance traveled. The same coefficient of friction was obtained through all our distance d .

Question 7: Do you expect ΔE to be positive or negative?

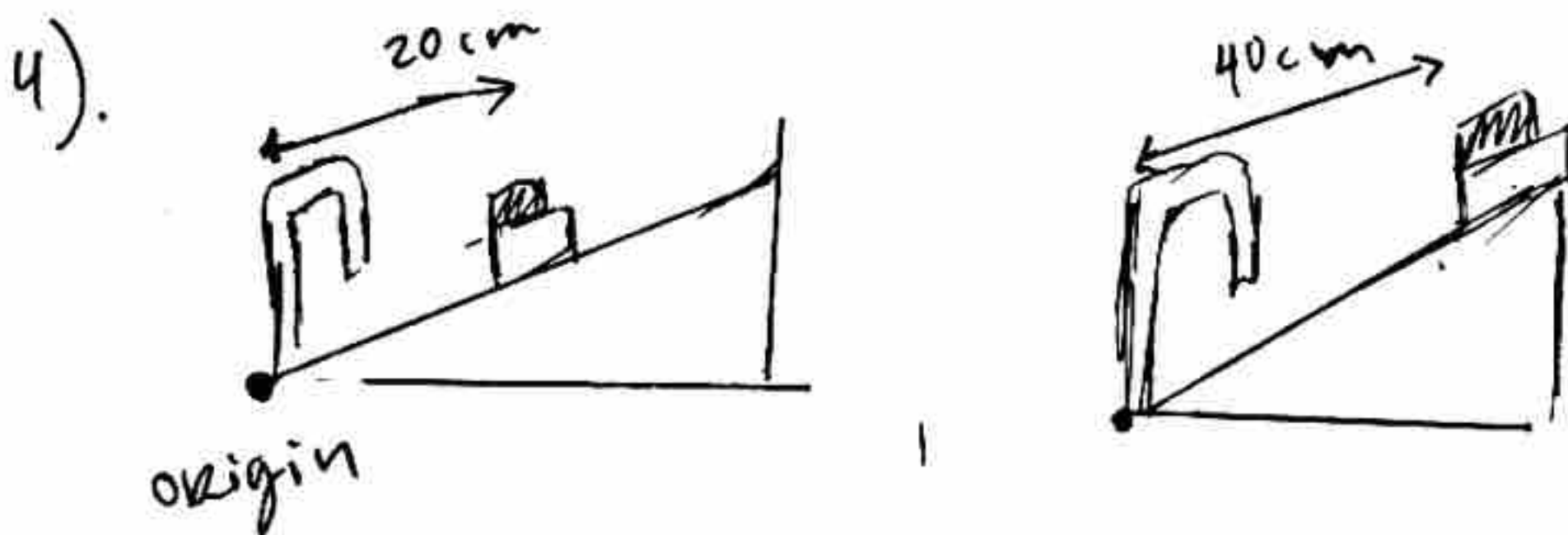
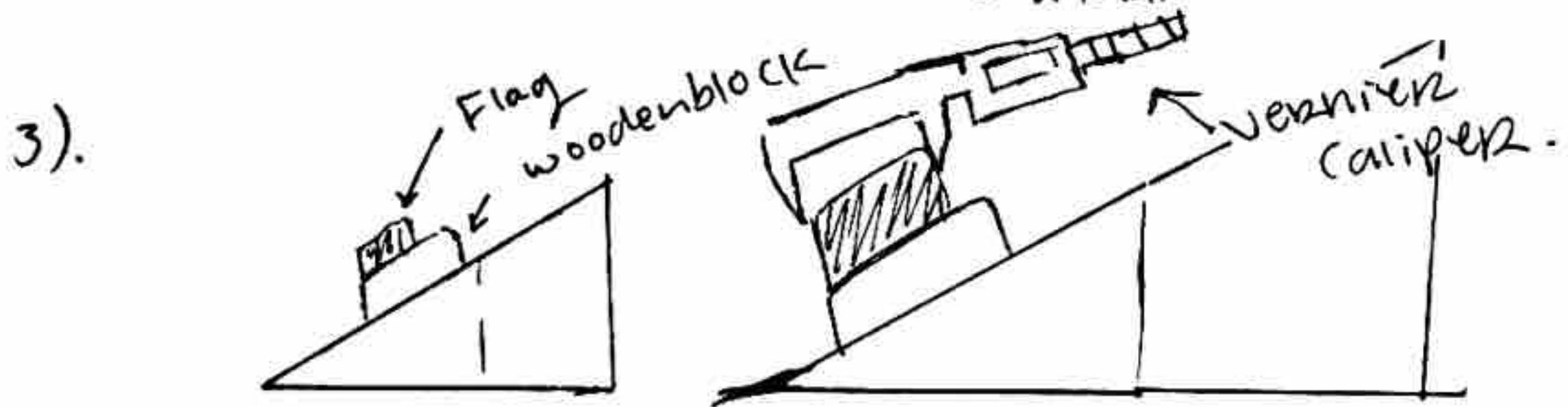
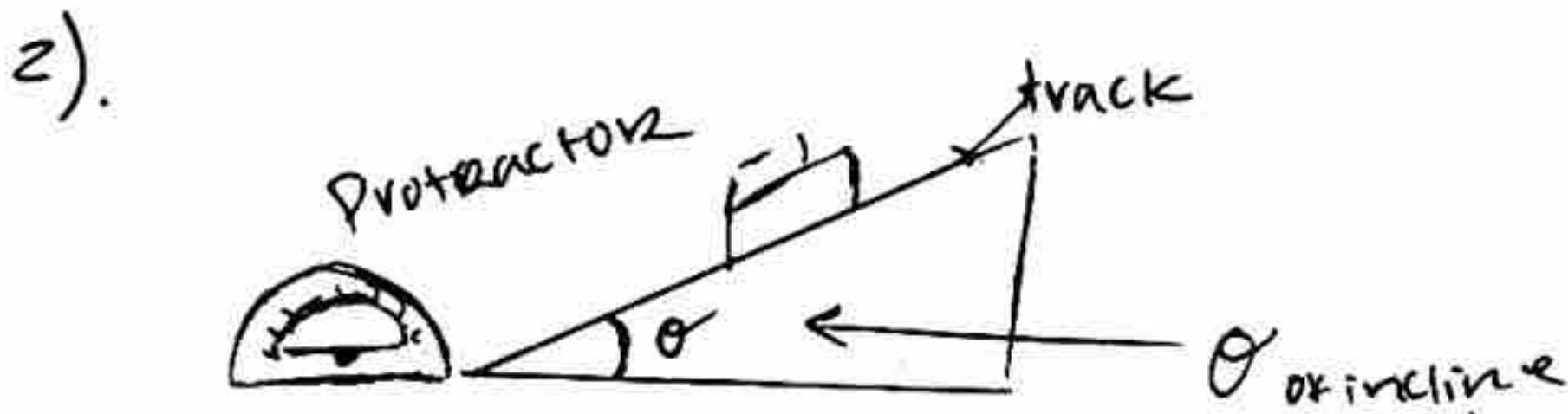
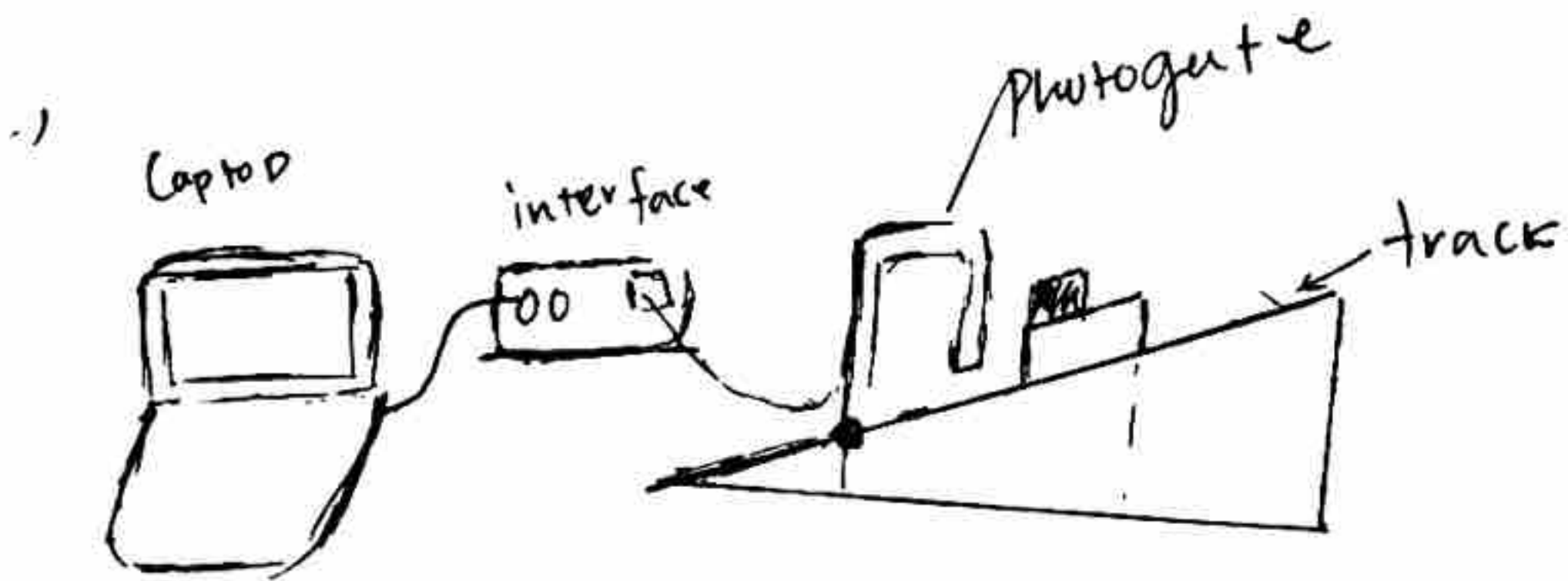
I expected my Change in Energy to be negative. The reason why I predicted this was because of the loss of energy; conservation of energy does not apply here. One of the non-conservative forces that acts upon the object is the Kinetic friction.

Question 8: Does the work of friction account for the loss of mechanical energy? If there is any deviation from zero, does it exhibit any trend as a function of d ? What possible reasons?

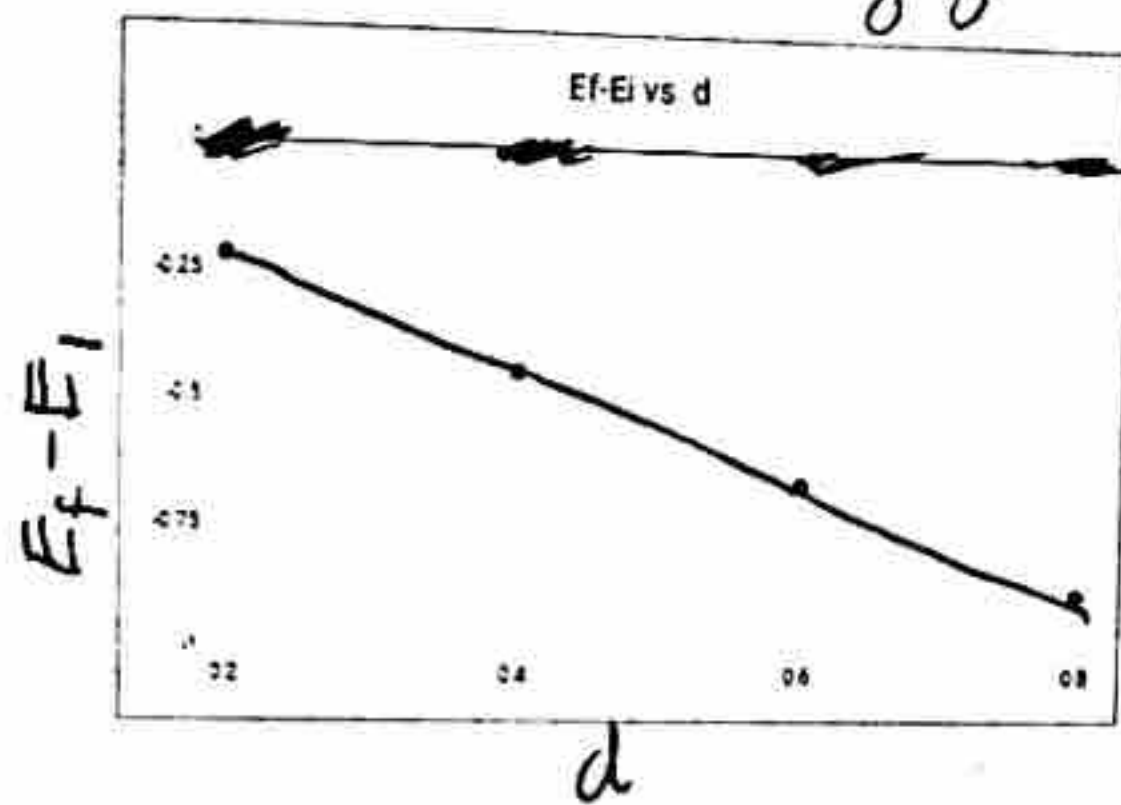
Yes, the work of friction does account for the loss of mechanical energy since the discrepancy were approximately zero at all places.

The deviation from zero is that it gets bigger as the distance gets bigger.

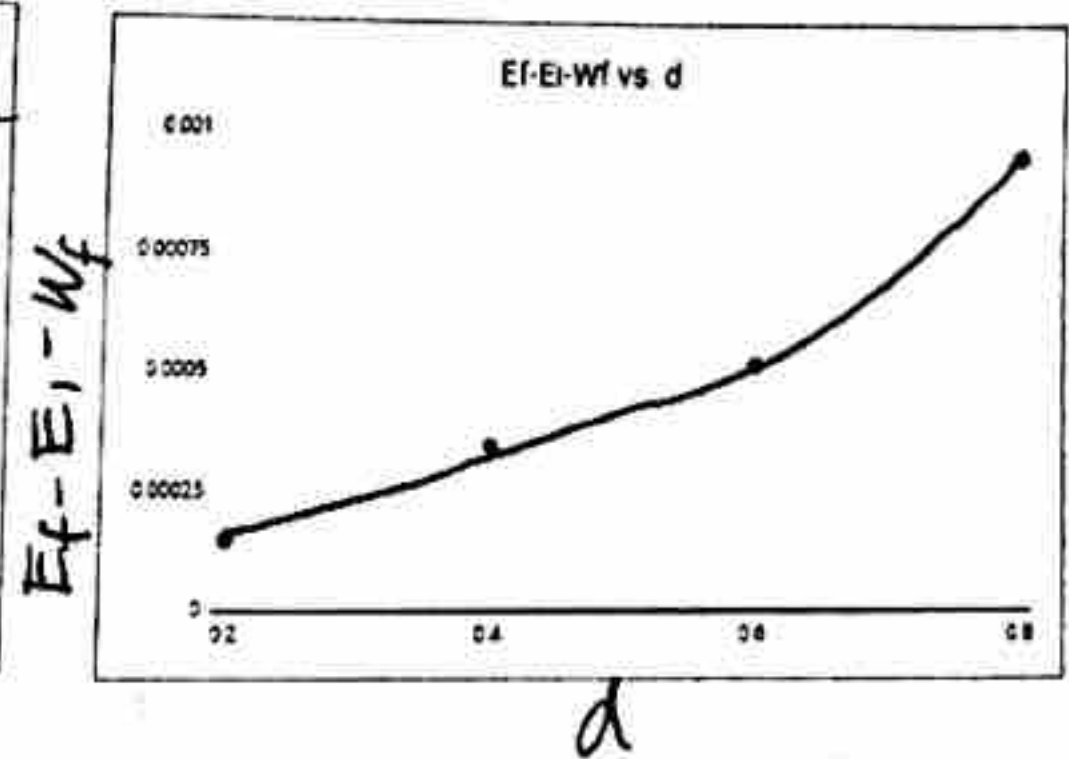
Procedure



ΔE
Loss of Energy



Work done by friction.



Data, Analysis and discussion

Table Activity 4.

d (cm)	d (m)	t (s)	tave (s)	KEi (J)	GPEi (J)	KEf (J)	GPEf (J)	Ef-Ei (J)	Ef-Ei-Wf (J)
20	0.2	0.18	0.164	0	0.354368	0.000245	0.132888	-0.221234	0.000144
20	0.2	0.16		0			0	0	
20	0.2	0.16		0			0	0	
20	0.2	0.16		0			0	0	
20	0.2	0.16		0			0	0	
40	0.4	0.11	0.11	0	0.575848	0.000545	0.132888	-0.442414	0.000344
40	0.4	0.11		0			0	0	
40	0.4	0.11		0			0	0	
40	0.4	0.11		0			0	0	
40	0.4	0.11		0			0	0	
60	0.6	0.09	0.09	0	0.797328	0.000814	0.132888	-0.663625	0.000513
60	0.6	0.09		0			0	0	
60	0.6	0.09		0			0	0	
60	0.6	0.09		0			0	0	
60	0.6	0.09		0			0	0	
80	0.8	0.07	0.07	0	1.018808	0.001346	0.132888	-0.884573	0.000945
80	0.8	0.07		0			0	0	
80	0.8	0.07		0			0	0	
80	0.8	0.07		0			0	0	
80	0.8	0.07		0			0	0	

L (m) 0.007642
 θ (deg) 30
 θ (rad) 0.523333
m (kg) 0.226

TABLE Activity 3

d (cm)	d (m)	t (s)	tave (s)	μ	f (N)
20	0.2	0.18	0.164	0.57699	1.108008
20	0.2	0.16			
20	0.2	0.16			
20	0.2	0.16			
20	0.2	0.16			
40	0.4	0.11	0.11	0.576989	1.108006
40	0.4	0.11			
40	0.4	0.11			
40	0.4	0.11			
40	0.4	0.11			
60	0.6	0.09	0.09	0.576989	1.108006
60	0.6	0.09			
60	0.6	0.09			
60	0.6	0.09			
60	0.6	0.09			
80	0.8	0.07	0.07	0.576988	1.108003
80	0.8	0.07			
80	0.8	0.07			
80	0.8	0.07			
80	0.8	0.07			

L (m) 0.007642
 θ (deg) 30
 θ (rad) 0.523333
 μ ave = 0.576990
50 μ = 1.01E-06
m (kg) 0.226