Student's Learning Activities
(Joule and energy)

Activity 1

You will watch a video with narration or listen to a story from your teacher about James Prescott Joule and on one important contribution by him in Physics. It is about the calculation of the mechanical equivalent of heat. Please write the most important points of the story according to your view and discuss them in your group. (Indicative important points of this story: the description of the device of the experiment, the process of the experiment, the conditions of the experiment, the difficulties which were for the effectuation of the experiment…)

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b. A simplified iconic representation of Joule's experimental device, you can find in a video at the following address:
http://www.youtube.com/watch?v=bZbTZN6V7YI&feature=topics

Which are the main parts of this device?
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Activity 2

Link to the following website http://www.youtube.com/watch?v=MBrTDKc9YZ0 to see the device Joule constructed for his experiments and the way it operates.
Please relate the points you can recall from the story from the video presenting the operation of the device, in order to answer to the following questions:
1. Which measurements and of which magnitudes are taken in the experiment?

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2. At which instances is the temperature of the water measured with the thermometer?
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3. Of which other magnitude is the temperature measured? Can you guess the reason why?
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Activity 3

After linking to the website:
http://www.hasdeu.bz.edu.ro/softuri/fizica/gimnaziu/experiment%20joule/www.einstein-support.co.uk/support/msim/website/experiment/exp_b_virtual_exp_flash_1.htm,

that reconstructs Joule's experiment please complete the following table that deals with Joule's experiment about the values of the fall of mass and the increase in the temperature of water in the experiment's container. We select a total mass of 10 lb. (2 bodies of 5 lbs each) and we let it drop 5, 10, 20 times from a height of 1m.

1. You have selected a mass of 10 lbs. and let it drop 5 times. The temperature increase in the water was 0,055 degrees ^{o}F.
2. You have selected a mass of 10 lbs. and let it drop 10 times. The temperature increase in the water was 0,109 degrees ^{o}F.
3. You have selected a mass of 10 lbs. and let it drop 20 times. The temperature increase in the water was 0,209 degrees ^{o}F.

The increase in the temperature of the water was 0,209 degrees ^{o}F.
Please transfer the data from the descriptions above in the table bellow.

TABLE 1		
Total distance that the weights cover when descending	Difference of temperature (°F)	Difference of temperature (°C)
5h= 5m		
10h =……		
20h …….		

Use the formula $\Delta\Theta(^oC)=\Delta\Theta(^oF).5/9$ in order to convert the difference in temperature that was measured in the Fahrenheit scale to the Celsius scale and write it down in the 3d column of the table.
On the basis of the data recorded in the 1st and 3d columns what conclusions can you draw about the relation between the height from which the bodies fall and the increase in the temperature of the water?

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Activity 4

The formula W=m.g.h is used for the calculation of the work produced through the fall of a body with a mass of m. The mass is measured in kg, where g expresses the acceleration of gravity (approximately 9,81 m/sec^2) and h the constant height from which bodies fall measured in m. We will use it in order to calculate the work produced during the fall of the weights of the device.
The heat produced in the cylinder with the metal wings which contains the water, is calculated with a complex procedure that concludes in the formula $Q=C_\theta.\Delta\theta$.
Q is measured in calories cal., $\Delta\theta$ expresses the increase in the temperature of the water in °C and C_θ expresses the thermal capacity of the calorimeter. We assume that a calorimeter such as the one in the video has a value of 1814 cal/°C.
On the basis of the values in table 1 and according to the relations described above we calculate the values of W and Q as well as the quotient Q/W for every measurement of the experiment shown in the video.

TABLE 2 For our calculations we assume that a mass m=10lbs equals 10/2,2 kg		
W = mgh	$Q= C_\theta\Delta\theta$ $Q= C_\theta\Delta\theta$	W/Q
W1={(10/2,2).9,81.5} joule =222,95 joule	Q1=1814.0,031 cal. =56.23	W1/Q1 =3.96

W2= ……………….. joule	Q2=………………….. cal.	W2 /Q2
W3= …………………….joule	Q3=…………………………cal.	W2 /Q2

Please discuss the values of the quotient Q/W.

Activity 5

As science evolved various experimental settings were used, new methods were applied and the relation between work and heat was calculated as can be seen in the table below:

Table 3
W=4,2 (Joule/cal) x Q . W is calculated in joule and Q in cal
Q= 0,24 (cal/Joule) x W. W is calculated in joule and Q in cal

Can you calculate the differences in the values in table 3 from those in table 2.
To which causes may these differences attributed?

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Activity 6

In the archive of the Royal Society of England one can find the volumes of the journal Philosophical Transactions into which the articles by Joule about the calculation of the mechanical equivalent of heat were published.

<u>Article 1</u>

III. *On the Mechanical Equivalent of Heat.* By JAMES PRESCOTT JOULE, *F.C.S., Sec. Lit. and Phil. Society, Manchester, Cor. Mem. R.A., Turin, &c.* *Communicated by* MICHAEL FARADAY, *D.C.L., F.R.S., Foreign Associate of the Academy of Sciences, Paris, &c. &c.*

Received June 6,—Read June 21, 1849.

"Heat is a very brisk agitation of the insensible parts of the object, which produces in us that sensation from whence we denominate the object hot; so what in our sensation is *heat*, in the object is nothing but *motion*."—LOCKE.

"The *force* of a moving body is proportional to the square of its velocity, or to the height to which it would rise against gravity."—LEIBNITZ.

IN accordance with the pledge I gave the Royal Society some years ago, I have now the honour to present it with the results of the experiments I have made in order to determine the mechanical equivalent of heat with exactness. I will commence with

<u>Article 2</u>

XI. *New Determination of the Mechanical Equivalent of Heat.*
By JAMES PRESCOTT JOULE, *D.C.L., LL.D., F.R.SS. L. and E., &c., President of the Literary and Philosophical Society of Manchester.*

Received November 15, 1877,—Read January 24, 1878.

THE Committee of the British Association on Standards of Electrical Resistance having judged it desirable that a fresh determination of the mechanical equivalent of heat should be made, by observing the thermal effects due to the transmission of electrical currents through resistances measured by the unit they had issued, I undertook experiments with that view, resulting in a larger figure (782·5)* than that which I had obtained from the friction of fluids (772·6).†

Which conclusions may be drawn from the comparison of the titles and the excerpts of the two publications in relation to:

1. The period of time between the two publications.

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2. The difference in the quality of scientific knowledge that Joule possessed during the first publication and that during the second.

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3. The status of Joule in the scientific community as this it can be shown by the titles that accompany his name in the two publications.

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4. In the beginning of both articles Joules makes reference to groups of scientists. Which are these groups and which do you think that was their role?

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Please discuss these questions in your group and prepare the answers so that you can present them in the discussion that will follow.

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