Mahatma Education Society's
Pillai College of Engineering, New Panvel

Department of Mechanical and Automobile Engineering

A REPORT ON
PROJECT BASED LEARNING

2019-2020

Class: Third Year **Branch:** Mechanical / Automobile Engg. **Semester:** V CBCGS

There were two PBL topics that were floated for the student groups to choose from, at the start of the semester. They were: (1) **Aeolipile (Heron's Engine)**
(2) **Keep It Warm**

A minimum of 2 students and a maximum of 4 students were allowed to form PBL groups. There were two stages of evaluation in the semester, a mid-term (Stage 1) and a final (Stage 2) evaluation, in view of ensuring consistency in the work done throughout the semester and giving feedback during the Semester so that students can improve their understanding of the topic and present a model during the final demonstration stage. Also, a separate period of 1 hour was allotted to the students per week for planning and carrying out PBL activity.

The **Problem Statement**, **Rubrics** for Stages 1 and 2 evaluations, and the conclusions drawn at the end of the activity are highlighted in brief, as follows.

PROBLEM STATEMENTS

(1) Aeolipile (Heron's Engine)

The Hero Engine

1 Problem Description

A hero engine or the Aeolipile is an ancient device that uses steam to produce rotational motion. Water is heated inside a chamber and the steam produced is released from a pair of nozzles. This produces a torque causing the device to rotate.

In the 1st century AD, Heron of Alexandria described the device, and many sources give him the credit for its invention. The aeolipile Heron described is considered to be the first recorded steam engine or reaction steam turbine. The name – derived from the Greek word Aeolic and Latin word pila – translates to "the ball of Aeolus", Aeolus being the Greek god of the air and wind.
Students will be asked to design in solidworks, generate a mathematical model and finally build and test the device. The device should be able to rotate at a certain peak RPM, for a fixed amount of time and it needs to be attached to a generator to generate a voltage of atleast 1V. The device will be developed in multiple stages. Students will be tasked to do the following

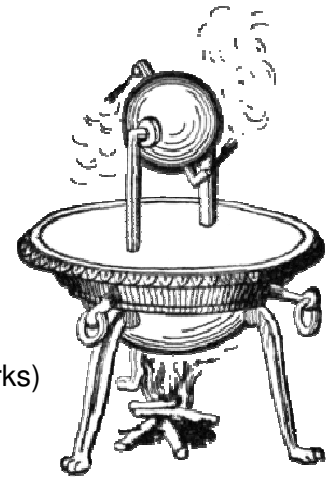


Figure 1: Illustration of an Aeolipile .

1. **Model the device** and derive equations for the following (20 marks)
   (a) Time required for the device to start spinning
   (b) Time required for the device to stop spinning

(c) The angular velocity for the device assuming no friction and and that the fluid is in- compressible

(d) The pressure that is developed inside the boiling chamber

(e) The torque generated when the chamber is prevented from rotating

(f) The relationship between the angular velocity and the voltage generated

2. **Detailed assembly drawing of the device** that includes the boiling chamber along with the nozzles, the attachment of the chamber to a generator or a motor with leads that can be used to measure the voltage. The device should be fixtured correctly such that chamber does not wobble. Students are encouraged to watch videos online (on youtube) of the different types of designs other people have developed. They should analyze pros and cons of the different orientations (horizontal and vertical) before picking their own design. Also note that the leads should not be rotating.

3. **Fabrication of the device**. The chamber must be made using materials that have a melting temperature of atleast 200 ◦C or above. Students should also try and use low friction bearings for the attachment of the chamber to the fixtures. There should also be a way to refill the device with water when needed and the reseal for further testing.

4. **Testing of the device** to measure the time to start and finish, the final angular velocity and the voltage generated. The device should be supplied with no more than 100 ml of water. It should start spinning within 1min of supplying heat and stop within 10 mins. Students should assume that we will be supplying heat with a candle or a burner that can generate heat of around 50 watts. Students should also ensure that the device is safe to operate

Rubrics:

Stage 1 Evaluation—Rubrics

Class: TE (Mech-A / Mech-B / Auto) **Group No. ____** **Date: 22** August 2019

Students' Names: 1._____ 2._____ 3._____ 4._____

Roll Nos.: _____ _____ _____ _____

Students' Signatures: _____ _____ _____ _____

Sr No	Calculations/Design/Material Selection	Done Y/N	Remarks
1	Theoretical Equations/Calculations for i) Time required to start the spinning ii) Time for which the device will spin iii) Angular velocity/Max RPM of the device iv) Torque generated when the chamber is prevented from rotating		
2	Axis orientation of the spinning device : horizontal/vertical		
3	Whether the spinning device will be separate from the steam generating chamber		
4	Materials selected for components : Should withstand temp of 200 ^{0}C		
5	Nozzle design : Inside diameter/No of nozzles		
6	Safety of the device considered		

7	How the steam pipes will be connected to the spinning chamber?		
8	Generating voltage: what device will be connected? How will the spinning chamber be connected to Voltage generator?		
9	SolidWorks Assembly/Component drawings/BOM		
10	Whether bearings are included in the design? What type of bearings?		
11	Estimated cost of the proposed design		

Overall Rating of PBL Work done (Stage 1):

Best Very Good Average Poor Needs a lot of improvement

Evaluators' Signatures: 1._____ 2. _____ 3._____

Rubrics Stage 2

PROJECT BASED LEARNING (PBL) DEMONSTRATION – RUBRICS & ASSESSMENT SHEET

Topic—Aeolipile (Heron Engine) Year & Class—T.E.-MECH /AUTO- Date of Demonstration—5/10/2019

JUDGES:

Signatures: _____ _____ _____ _____

STUDENT GROUP NO. —

NAME				
ROLL NO.				
SIGNATURE				

TERM-WORK MARKS ALLOCATION:

SUBJECT	HT(/10)	MMC(/10)	DOM (/05)
MARKS ATTAINED			

1. Modelling of the device/calculations done : (Y/N)
   i) Time required for device to start spinning_____
   ii) Max RPM_____
   iii) Torque generated when the chamber is prevented from rotating_____
2. CAD Drawings prepared for components and assembly: ____
3. Axis orientation : Horizontal/Vertical
4. Is the steam generating chamber separate from the spinning device: _____
5. Material selection
   i) Steam generating chamber :_____
   ii) Spinning device: _____
   iii) Steam pipes (if applicable):_____
   iv) Bearing (if used) :_____
   v) DC Motor or Cycle Dynamo (if used):_____

vi) Supporting frame: _____

6. Nozzle design/Inside Diameter/Material :

7. Testing of the Device :
   i) Time(s) observed: _____ sec
   ii) RPM (Max) observed: _____
   iii) Voltage generated? : (Y/N)_____ V

8. Is any wobbling of the spinning device observed? _____

9. Manufacturing/fabrication/joining processes used _____

10. Safety of the device: _____

11. Report prepared : (Y/N)

12. Approx. Cost of the Project: Rs. _____
    i) Material cost :
    ii) Assembly/Fabrication time :

13. **Overall Device Quality** (Rate from 1-5, 5 being the best): _____

14. **Overall Remarks of PBL Work** (Rate from 1-5): _____

15. What improvement can be done in the device?
    _____

(2) Keep It Warm

Problem Statement:

To design and manufacture an insulated container which will keep 250 ml of heated water warm for as long as possible. The maximum size of the container allowed is 200mm x 200mm x 200 mm. The container must have provision for easy insertion and removal of standard mercury – in – glass thermometer to measure the temperature of water. The shape, material of container and the material of insulation should be decided by the students and proper mathematical modeling and theoretical prediction must be done by students before actual fabrication.

Following are the additional points to be noted:

1) The test duration will be approx 45 minutes from the time heated water is put inside the container. Target of the project is the student group should predict the temperature profile with respect to time and the maximum difference between the predicted and measured temperature should not exceed 2 ^{0}C. The starting point is the measured temperature of heated water as it is put inside the container. With this initial temperature, students should be able to predict the temperature after @ 45 minutes which will be compared with the measured value.

2) There should be no energy source inside the container (e.g. no electrical components, small battery powered heaters, chemically reacting material, etc.

3) The cost of the container should be kept minimum. Also no hazardous material should be used in the container.

Outcomes:

Students will learn

1. Use of 3D CAD software for modeling and simulation of their design.
2. Basics of heat transfer due to conduction, convection and transient heat transfer will be understood.
3. Basics of modeling – mathematical, analytical, software and experimental models will be known.
4. Basics of fabrication using CNC, laser cutting, 3D printing or any other fabrication technology.

Evaluation Schedule:

Stage 1 (Design and Mathematical Modeling): 25/8/2019

Stage 2 (Final Demonstration and Testing) : 5/10/2019

Rubrics:

Stage 1 Evaluation—Rubrics

Class: TE (Mech-A / Mech-B / Auto) **Group No. ____** **Date: 22** August 2019

Students' Names: 1._____ 2._____ 3._____ 4._____
Roll Nos.: _____ _____ _____ _____
Students' Signatures: _____ _____ _____ _____

Sr No	Calculations/Design/Material Selection	Done Y/N	Remarks
1	Brainstorming conducted ? How many different designs/shapes were considered before finalizing the design?		
2	What will be the shape/cross section of the container ?		
3	Theoretical calculations done for prediction of water temperature with respect to time from an initial temperature T_i ?		
4	Materials selected for components i) Outside container ii) Insulation iii) Water containing chamber		
5	Provision for inserting and removing of mercury-in-glass thermometer		
6	SolidWorks Assembly/Component drawings/BOM		
7	What problems do you anticipate during fabrication/testing of the insulated container /		
8	Estimated cost of the proposed design		

Overall Rating of PBL Work done (Stage 1):

Best Very Good Average Poor Needs a lot of improvement

Evaluators' Signatures: 1._____ 2. _____ 3._____

PROJECT BASED LEARNING (PBL) DEMONSTRATION – RUBRICS & ASSESSMENT SHEET

Topic—Keep It Warm Year & Class—T.E.-MECH /AUTO- Date of Demonstration—5/10/2019

JUDGES:

Signatures: _____ _____ _____ _____

STUDENT GROUP NO. —

NAME				
ROLL NO.				
SIGNATURE				

TERM-WORK MARKS ALLOCATION:

SUBJECT	HT(/20)	MMC(/05)
MARKS ATTAINED		

15. Have any calculations for prediction of temperature wrt time been done ? Plot prepared ? What analysis method in Unsteady State Heat Transfer is applied ?

    _____

    _____

    _____

16. i) Shape of the Container :_____

    ii) Overall dimensions : _____ L *_____W*_____H
    OR _____Dia *_____H

3 Materials Used :
   i) Inner Container :
   ii) Insulation :
   iii) Outer Container :
   iv) Any other component/part :

4 Provision for easy insertion and removal of standard Mercury-in-glass thermometer done: _____

5 Test Report :
   i) Initial temperature of water :_____ ^{0}C

   ii) Initially after every minute (for first 5 minutes):

   ____ ^{0}C ____ ^{0}C ____ ^{0}C ____ ^{0}C ____^{0}C

   iii) After first 5 minutes, take readings after every 5 Minutes.Does the water temp attain steady state?

   _____

   _____

   _____

   iv) Record the temperature after 45 minutes from the start of the Test._____ ^{0}C

6. Compare measured values wrt predicted :

   _____

7 Approx. Cost of the Project: Rs. _____
   i) Material cost :
   ii) Assembly/Fabrication time :

8. Overall Device Quality (Rate from 1-5, 5 being the best): _____

9. Overall Remarks of PBL Work (Rate from 1-5):

   _____

10. What improvement can be done in the device?

    _____

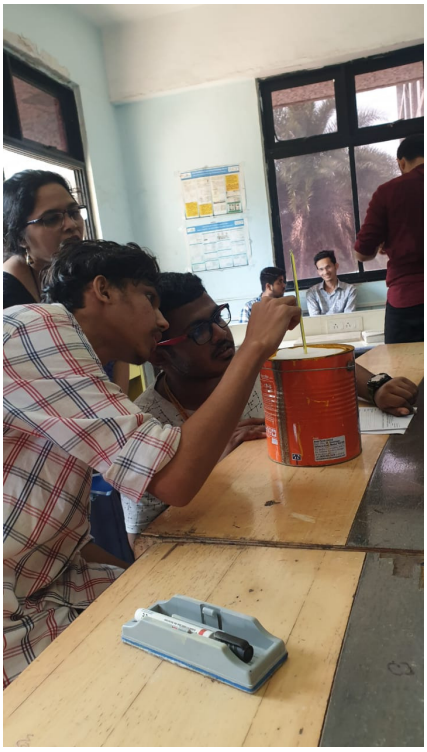
SAMPLE PHOTOGRAPHS of some PBL PROJECTS & EVALUATION:

Final Demonstration of a sample Heron's Engine being shown to CEO, Dr K M Vasudevan Pillai, Principal Dr S M Joshi and Visitors to Campus

Sample Projects of Heron's Engine being demonstrated by the Student Groups

COO, Dr Priam Pillai keenly observing
a sample Demonstration

Sample PBL Demonstrations of Keep It Warm



Sample piece of Container as per Specifications of Keep It Warm

Faculty member guiding the Student Group for taking measurments

CONCLUSIONS & OBSERVATIONS

The Project Based Learning technique is used in our Institute effectively to enhance students' understanding of basic concepts and their application to a live problem. Student groups were found to participate energetically in the project based learning activity, with roughly an equal number of groups pursuing either topic depending on their interests.

It was found that the PBL objectives set at the start of the activity were largely met, although many groups had difficulty in understanding and putting the theory into practice. Hence, it can be regarded without doubt, that the project based learning is a very efficient tool to implement concepts understood in theory into practice.

With the thrust on PEO's (Program Educational Objectives), PSO's (Program Specific Objectives), PO's (Program Outcomes) and CO's (Course Outcomes) it is imperative for the Institutes to incorporate innovative teaching learning methodologies. PBL is one such tool which helps students to apply the engineering principles in design, fabrication and testing of a device or mechanism to accomplish a stated goal.
