Wooden-Works Tall-Case Pendulum Clock
Design / Build Project
Mechanism, Control, Energy, Fabrication

Note:
Search on "assignment" or "marks" for the work to do and drop off by end of class two days after the date at bottom of this page.
And do the Sept. 28 "Energy Control Application: Pendulum Clock" Moodle quiz.

CONTENTS

1 Project Definition – For Your Design Brief

As an enthusiastic member of a determined collaborative group, to design and build a ***wooden-works pendulum clock*** which accurately "tells time".

Each design team member will perform a management role as defined in Design_Team_Roles.doc. Team members will be individually responsible for the product documents as outlined in Design_Team_Roles.doc.

In addition, each team member will be responsible for at least one technical sub-system of the clock, including investigation / research, design, build, evaluate / test.

2 Sub-System Identification – Simplify the Problem – Break it Down

As usual, it is very important to first simplify a problem by breaking it down into much more manageable and understandable sub-systems. Each member of the team will be responsible for the design of a sub-system of the wooden-works pendulum clock, as follows:

#	Sub-System	Assigned Student(s)	Notes
1	Input Energy		The energy of the falling weights. The weights are the potential energy which actually operates the clock. (With user instructions to periodically raise the weights back up again.)
2	Output Interface		The clock's time display – must be an accurate

#	Sub-System	Assigned Student(s)	Notes
			representation of the passage of time.
3	Measurement of Time		The pendulum and its properties. This is an indirect measurement system. Receives periodic pulses of energy (through the escapement sub-system) to offset friction losses in the pendulum and other sub-systems.
4	Power Transmission		Transmitting the energy through the clock system from input to output. This sub-system must preserve the accuracy of the pendulum time-measurement system.
5	Escapement		Controlling the release of the input energy pulses. Each pulse of energy to keep the pendulum swinging coincides with an incremental count of the time (as kept by the pendulum).
~~6~~	Structural Frame / Carcase		A framework of some kind must hold all parts in a fixed relationship with one another, allowing only the relative movement of functional parts that is required under the design intent The clock case: stability; size; aesthetics

Notes:

1. Output from one sub-system is input to another sub-system(s). Accordingly, every day team members must communicate clearly with each other. The Project Manager will keep minutes of these meetings and assign and track tasks accordingly.
    a. For example, the energy of the falling weights interfaces with the escapement sub-system which interfaces with the power transmission sub-system which interfaces with the time display sub-system – seconds, minutes and hours.
    b. Each individual on the team is responsible for clearly identifying and communicating his / her sub-system interfaces with other members.
    c. In other words, team members cannot work in isolation. The team has a common goal. Collaboration is key.
2. The clock is to be "Wooden Works", that is, the gears in the power transmission and escapement sub-systems will all be made of wood.

3 General Requirements

For their chosen sub-system and management role, students must follow the entire design process, including product documentation. In each student's own sub-system requirements document, you must address the seven or eight most significant of the 13 fundamental concepts of technological education. Every student must specify his or her requirements, both for the assigned product sub-system and for his / her own learning. This must be documented in the "Sub-System Requirements Document".

There are some "fundamentals" that must come along with this project including skills practice, assignments, quizzes. The student will use the design process, core thinking skills and other essential skills, good work habits, problem-solving strategies and other best practices as presented in this course.

4 Time / Project Management -- Plan -- A Goal a Day -- Reflect

The teacher will not manage your time for you. Planning is a skill that needs to be appreciated and practiced. According to the Tech Studies curriculum planning is roughly one third of your "Thinking" Achievement category. You need to get the project – as you define it up front -- completed by the deadline. For your project management, use a simple table in MS Word with columns as shown below.

Date (mdy)	**My Goal Today (Planning)**	**What I Achieved Today (Reflecting)**	**Comments / Problems (eg Things Still to Do)**
9/30/16	-Design Brief -What Makes it Tick assignment		
10/4/16	-Research V1 – including Mechanism_Innovation.doc -brainstorming		
10/6/16	-Research V2 -Requirements doc ("what") for your sub-system		
10/10/16	-Specifications V1 ("how")		
	Preliminary design of …		
	Peer assessment of prel design of …		
	Etc – you define additional daily goals / targets		

5 Assessment / Evaluation

Group marks are not assigned in any way. Marks are based on the achievements of and results produced by individual students. If a team of two or three is assigned to a sub-system, the team members will fairly divide up the work according to Design_Team_Roles.doc. The team will formally assign tasks in a table-format Task List. All students on the team must work to plan and build the product according to assigned sub-system and management role. The Task List must be kept up-to-date by the Project Manager.

Evidence of your learning that will be evaluated will include:

- Design Portfolio:
    - **Pre-Production documentation** includes the design brief; research / investigation report; requirements document; sketches; parts and materials list, task list; fabrication plan
    - **Inventor Pro 2014** must be used for design / modelling work – including master.ipt; master.iam, generated ipt files and all part and assembly shop drawings (.idw files). The Middle-Out design methodology is highly

recommended for the individual design work. The "Cut List" based on the assembly Bill of Materials must be shown on the sub-system assembly .idw file.
    - **Post-Production documentation** includes the user guide; installation guide; markings / labels; test plan; test results / report; project reflection.
    - Your design portfolio must have a Table of Contents and all files must be in a consistent format – you should already have your own aesthetically-pleasing document design template.
    - All design documentation must meet the minimum requirements for the particular type of document. (Refer to Design_Team_Roles.doc and Written_Report_rubric.doc for details)
- The finished product itself

- The ultimate question is: ***"Are you so proud of your work that you would enthusiastically show it to the interviewer at a job interview"***?

6 General Resources

Some general resources to be used are already available in the pickup folders. Be sure to use and refer to:

Resource Document	Why -- Relevance and Connections
Process_Control.doc	Is a pendulum clock a bonafide "control"? Is a pendulum clock a control system? If so, what kind?
Mechanism_Innovation.doc	Full of inter-connected mechanisms, the pendulum clock was an ingenious invention.
Rubrics: Fabrication_Rubrics.doc Written_Report_Rubric.doc Rubric_Information_Processing.doc	To get a better mark: -Shop application work – measurement, hand, and machine skills -Communication – written, structured data, visual / graphic -Thinking – planning, problem-solving, information processing
Design_Process_Stages_Details.doc	The Design Process is one well-proven strategy for both "Problem-Solving" and "Opportunity-Achieving".
Design_Team_Roles.doc	Project Management – be accountable for one of the management elements.

7 Pendulum Clock "Quick-Start"

There is a good deal of useful information on the internet regarding pendulum clocks, for example:

- http://myreckonings.com/wordpress/2007/11/19/the-not-so-simple-pendulum
- http://www.wooden-gear-clocks.com/
- http://en.wikipedia.org/wiki/Longcase_clock

7.1 The Evolution of an Innovation ... Meeting a Need – the Pendulum Clock

Years ago, much as they do now, people needed to get something done by a certain time. As society became more complex, it wasn't just a case of saying "do it now". Society needed a standard for time that was more precise than just the position of the sun in the sky (if you could even see the sun). So the problem was *"what 'time' is it right now?... so I can get that job done 'on time'".* So...

- The sun was unreliable in terms of measuring time as accurately as society wanted
- People needed to measure time accurately on a standard scale – so days, hours, minutes... and then seconds were decided upon
- People looked for natural processes that follow a regular predictable pattern such that that natural process could be used to indirectly measure the passage of time in seconds, minutes, hours
    i. The swing of a pendulum of a constant / unchanging length fit the bill... so the earliest pendulum clocks came to be invented. The swinging pendulum is the time-measuring element.
- Measuring anything takes effort – or energy.
    i. Falling weights could provide the energy to run the new "time measuring machine"
    ii. As such, the falling weights could run the "time indicating" part of the clock – to "tell us what time" it is right now.
- Control the supply of energy to the system (made up mostly of the time-measuring and time-indicating sub-systems)
    i. The escapement in the pendulum clock allows pulses of energy – input -- from the falling weights to make up for losses due to friction
    ii. The input energy pulses are timed to coincide with the swing of the pendulum, simultaneously activating mechanisms to increment the time display – output -- by one unit
- The swings of a pendulum need to be counted... people did not have time (nor the patience) to count swings themselves.
    i. A controller mechanism (gears / pulleys / needles) was devised to transform the counting of pendulum swings into a visual representation that was more convenient for people – the circular clockface was invented.
    ii. Think about it... if the pendulum clock "counts" swings of a pendulum, the pendulum clock is fundamentally a digital machine. Yet we view the circular clock face as the quintessential analog device. You might say, a bit ironic!
- The length of the pendulum rod can actually vary with ambient temperature, depending on the material used for the rod.
    i. How could a pendulum clock be made to "compensate" for the effects of temperature change, in order to accurately represent time regardless of the ambient temperature?

7.2 Control System Connection – Think About This...

Control systems is a huge area of engineering and product design practice. Review the Process_Control.doc and, as you do, think again about the pendulum clock:

1. Is a pendulum clock actually a control system of some kind? What kind?
2. Can a pendulum clock be adapted to have a role in a control system?
3. Does a pendulum clock just have a control system built into it?
4. Is a pendulum clock simply a primitive "indicating control" (to tell us the time) and nothing more?

8 Critical Thinking Research Assignment – "*What Makes it Tick*" – 10 Marks (T)

The following assignment is due in the drop-off folder by the end of class two days after the date at the bottom of this page.

1. Consider the following statement.

   The "escapement" in a tall case pendulum clock is neither a control nor a mechanism, but is, rather, some kind of hybrid of these two fundamental concepts of technology.

   Do you agree or disagree with this statement? Explain your rationale. Discuss your analysis of the escapement – just what is it... fundamentally? (10 marks)