FIRE PROTECTION ENGINEERING DESIGN CHALLENGE MANUAL

Department of Fire Protection Engineering
University of Maryland

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SECTION 1 - OVERVIEW OF THE CHALLENGE

1.1 Overview

By participating in the Fire Protection Engineering Design Challenge[1] students will learn basic fire protection engineering concepts. Their efforts begin with an overview of fire behavior and fire protection subsystems. Materials—videos and written documents—are provided to students that include background information of core fire protection strategies and demonstrations; while demonstrations can be viewed via identified online resources, they could also be performed in a controlled environment at the high school. Materials are also provided to enable instructors/mentors to engage students in discussions or breakout group challenges. Once the foundation is established, students work in their pre-formed teams (see Section 2) to design a small-scale structure with creative detection and suppression systems designs. This portion of the design challenge allows students to gain experience in creative design and construction while applying fire protection engineering fundamentals. The Challenge culminates in a burn day held at a location in central Maryland. Should the number of participants grow appreciably, a preliminary round of experiments may be conducted regionally, with only finalists participating in the final day. Performance metrics are provided (see Sections 1.4 and 3) to select award winners in the Challenge.

1.2 Objectives

By participating in the project, the students will:

- Understand the guiding principles of fire protection engineering
- Gain experience in creative design and construction
- Practice the scientific method to formulate and test hypotheses
- Gain confidence in their ability to succeed in STEM

1.3 Description

The challenge presented in this project is to create a design for a 2-room apartment that accomplishes 3 principal objectives:

- Provide early detection of the fire and appropriate notification to occupants of the structure to allow for effective egress.
- Provide effective fire suppression in order to limit fire spread throughout the room of origin.
- Realistically represent the living conditions and fire load of a typical apartment.

1.4 Evaluation Criteria

Five metrics will be used to assess the effectiveness of students' proposed designs. Section 3 of this document provides a more detailed overview of each assessment metric as well as a sample of the Judging Rubric.

- Livability: accounts for the realistic nature of the contents of the space, including furniture composed of soft materials, carpet on the floors and wall linings.
- Response time of detector: needs to include some indication that detection has occurred.
- Time for suppression: time for fire to be controlled by the suppression system.

[1] Hereinafter referred simply to as the Challenge.

- Spread to other Objects: is the fire confined to the area of origin.
- Cost: total estimated cost, including the value of any donated materials.

1.5 Strategies

Students may view instructional videos on five core fire protection engineering strategies relevant to this challenge:

1. Material Flammability
2. Compartmentation
3. Ventilation
4. Detection
5. Suppression

In school mentors/teachers and professional mentors will have access to a Teacher/Mentor Laboratory Demonstration Guide. The Laboratory Demonstrations Guide will provide demonstrations and activities to serve as reinforcement for the instructional videos.

1.6 Help/Support

- A teacher, counselor, or advisor at each participating school will be identified as an in-school person of contact for student teams. This document will refer to these participants as 'in-school mentors.'
- Alumni of the FPE department at University of Maryland, or professional fire protection engineers, are assigned to each school to lend assistance for the student teams. This document will refer to these participants as 'professional mentors.' Professional mentors will work with the school teams in a virtual and/or in person capacity to provide guidance, additional support, any needed lecture video clarifications, and possibly demonstrations (depending on school policies) as teams progress in the Challenge.
- The suggested Laboratories Demonstration Guide is available for teachers and the professional mentors to use with the teams. Safe fire testing is best accomplished in a chemistry classroom/lab fume hood or out of doors when there is no wind and students can be a good distance away from combustible materials. The professional mentor or The Director of the program can be consulted regarding any questions about how best to keep testing safe.
- Any questions or concerns regarding the Challenge can be directed to enfp@umd.edu and/or the current Program Director.

1.7 Timeline

The annual competition will be announced in September each year. Team applications are due in late October. The Challenge officially begins in early November and ends with 'Burn Day' in early April. There are two suggested timelines based upon school participation frequency: a weekly club/school group or as a part of class curriculum.
*Most schools participating as a part of class curriculum do not begin the Challenge until spring session or in January. Schools should consider the timeline carefully depending upon their participation frequency.

Club/School Group Participation (meeting weekly):

- Early November to late December – watch the Opening Session (if you did not have a live/in person Opening Session) then all lecture videos. The recommended order in

which to introduce each of these topics is: Fire Behavior and Materials Parts 1 and 2, Fire Dynamics Parts 1 and 2, Compartmentation and Ventilation, Fire Detection and Notification and finally Fire Suppression. We provide to the Teacher/Mentor a suggested Laboratory Demonstrations Guide that can be used in conjunction with or in place of the lecture videos. This being said, in-school mentors should use their own discretion and student familiarity with the subjects when determining which, if all, videos to present and in which order.
- January and February – design systems; build basic structure; test system components
- February to March – build systems; further test system components
- March to early April – incorporate all components in the structure and prepare for burn tests
- Early April – attend Burn Day, final testing event and competition

In Class Participation (meeting multiple times a week):

- January – watch the Opening Session (if you did not have a live/in person Opening Session) then all lecture videos. The recommended order in which to introduce each of these topics is: Fire Behavior and Materials Parts 1 and 2, Fire Dynamics Parts 1 and 2, Compartmentation and Ventilation, Fire Detection and Notification and finally Fire Suppression. We provide to the Teacher/Mentor a suggested Laboratory Demonstrations Guide that can be used in conjunction with or in place of the lecture videos. This being said, in-school mentors should use their own discretion and student familiarity with the subjects when determining which, if all, videos to present and in which order.
- February – design systems; build basic structure; test system components
- February to March – build systems; further test system components
- March to early April – incorporate all components in the structure and prepare for burn tests
- Early April – attend Burn Day, final testing event and competition

SECTION 2 – TEAMS

2.1 Build Teams

The Challenge will accommodate as many teams as are created at each participating school. Each team should be composed of no less than 3 students and no more than 5 students. Embrace diversity of talent and background – teams involving students with different perspectives, skills, and interests are usually successful in projects like this. No technical expertise is required to participate in the Challenge. All teams will receive the necessary background or instruction on key fire protection engineering concepts—through professional mentors, the curriculum/lecture videos—to effectively participate in the program.

Outside of instructional time with in-school mentors and professional mentors, students are encouraged to arrange times with their team members to meet and brainstorm their designs. Student teams should follow all specific school requirements for student group gathering on or off school premises.

2.2 Register Your Team

Once teams are formed, each team is required to complete a Student Team Application. Additionally, each participating student is required to complete a Consent and Release Form and return it to the Associate Director for Programs at UMD *(Nicole Hollywood)*. Please note that these steps are required for your team to be formally recognized as a participating team and for all members of your team to participate.

2.3 In-School Mentors

In-school mentors are typically teachers who have volunteered to support the participation of students in the Challenge. By offering to serve in this capacity, teachers are making a commitment to make classroom space/s available, during and/or after school hours, to be utilized by professional mentors and student teams for instructional purposes[2]. Teachers will also supplement the guidance provided by professional mentors by checking in regularly with student teams and supporting them as needed. When necessary or appropriate, teachers will also serve as liaisons between the FPE department at the University of Maryland and student teams. Teachers will collect all students' completed Consent and Release Forms, scan, and send them to the Department of Fire Protection Engineering via the current Program Director.

2.4 Professional Mentors

Following the formal recognition of each student team by the FPE department at the University of Maryland, teams will be informed via the department's correspondence with in-school mentors of the assigned professional mentor/s. Mentors are expected to meet with students 4-6 times over the course of the Challenge to clarify concepts, conduct lab demonstrations, and provide mentoring. Outside of these prescribed instructional days, professional mentors may also be reached through their contact information that will be shared in the department's initial correspondence with in-school mentors.

SECTION 3 – EVALUATION

3.1 Evaluation Criteria

The Judging Rubric provided below identifies the categories that will be used to evaluate the performance of the design in each student group submittal. However, please keep in mind that your systems should not be overly sensitive with particular attention to the first criteria: livability. In real life, alarm systems, for example, need to be carefully designed so that they do not create nuisance alarms (or, more commonly known as 'false alarms') easily. It should be possible for systems to be able to be scaled up to a real life 'idea' and also should protect the entire space (no matter where a fire might occur).
Criteria Include:

- Livability is a category for judging the realistic nature of structure and furniture. For comfort, people prefer to have cushioned furniture and not have furniture made of steel and concrete placed in rooms with no windows. Such furnishings are not representative of an apartment most people would live in. While a fire protection engineer would generally be concerned about limiting the amount of combustible material, some combustible material is inherent in any bedroom.

[2] Our expectation, given past iterations of the Challenge, is that professional mentors will require access to classrooms 1-3 times over the course of the program.

- Response Time is considered because faster (and more importantly efficient) detection and activation of suppression systems is typically desired. Small fires are generally easier to suppress than larger fires. Further, preventing a small fire from becoming a large fire is a basic fire safety strategy to limit the severity of the hazard to people or exposed objects. NOTE: to limit the potential for unnecessary, or "false," alarms, detection of a fire should not occur prematurely or from non-fire sources (e.g. flash from a camera, or the pilot source (initial lighting of the fuel source) of the fire in the model).

- Time for Suppression considers the time it takes to stop the growth of the fire. Even though a system may activate quickly, if it is not capable of limiting spread or extinguishing the fire, the fire will continue to burn. All fires will be allowed to burn for a maximum of 5 minutes (experiments may be terminated sooner if judged that the suppression systems have failed).

- Spread to other objects shows whether the fire is contained prior to spreading from the area and/or room of origin.

- Cost Detection and suppression systems only become viable if they are effective and affordable. Hence, the total estimated cost is considered, including the value of any donated materials.

3.2 Judging Rubric

All buildings will be evaluated using the following rubric. The best designs will be those with the *lowest score*.

Judging Rubric	Category Points	Points
Livability	[1-5] (1=best)	
Detection Time	[seconds]*	
Notification Time	[seconds]*	
Suppression Activation Time	[seconds]*	
Suppression Effectiveness	[1-5] x 5 (1 = best)	

Spread to other objects	[# of objects involved in fire] x 5	
Creativity	[1-5] (1 = best)	
Total Estimated cost	[$]/10	

*If action was not achieved = 300.

3.3 Building Requirements

Requirement	Details
Structure	The structure will be 18"x12", with a ceiling height of 12". A glass wall will be provided for 1 long wall, all other walls, floor and ceiling must be solid, opaque materials. There will be two rooms: one 12"x12", and one 6"x12". The ceiling **MUST** be removable, though when put in place should fit reasonably well. The interior must be accessible for inspecting the furniture and for igniting the fire.
Systems	Systems that reach more than a foot above the roof must be approved prior to construction. Systems must remain within the footprint of the building. No systems design may include any explosive item (batteries of any kind, aerosolized containers, etc.). Power sources needed for any of the systems should be external to the model structure. If batteries are needed in the systems design, they must be placed at a location outside the structure, other than on the roof.
Openings	There must be **one** doorway (6.5" x 2.5") leading out of the front room of the compartment (to outside) and **one** doorway of the same size connecting the two rooms by means of the interior wall. There must be **one** window on two exterior walls for the larger room (two windows.) Windows must be at least 3" wide and 2" high, not to exceed 9 in^2 in area. Openings may be closed as part of the design, but must be open initially.

Furniture	See Furniture Requirements below. Furniture should be movable, to be put into position by the University team on the day of the test.
Wall and Floor Finishings	Carpet must be provided for the floors of both rooms. Curtains for the windows and at least one 3" x 3" "poster" must be included.
Money	Each team may spend up to $50 for materials used for the project. All materials must be accounted for, even if donated or free samples. Teams will be provided with an Arduino kit which need not be included in their budget.
Arduino *(Optional)*	The most relevant components used with the arduino for this project are a photoresistor or a thermistor. *Photoresistor*: the photoresistor **must not** activate upon use of flash photography. *Thermistor:* the thermistor **must not** activate upon the use of a pilot source. Note: Teachers may choose to utilize provided arduino assistance located in the Fire Protection Engineering Design Challenge: School Resources shared google drive (access must be provided by the Associate Director, email enfp@umd.edu).

3.4 Furniture Requirements

Each team must build and furnish their room with the following furniture. The furniture must be representative of real furniture, i.e. materials selected for furniture must be similar to materials used in actual homes and incorporate materials such as foam plastic, cotton, wood, and cloth. The materials provided by the Director of The Challenge should be what is used to create the furnishings that provide liability (popsicle sticks, foam, felt, cloth, etc.) to standardize the 'fuel package' created in the fire test at the Burn Day event. If a school feels that they need more materials, they should reach out to The Director.

Qty.	**Furniture**	**Size (LxWxH in inches)**
See shared file "FPE DC Dimensions" in Building Your Structure for placement:		
2	Bed	6 x 3 x 2, composed only of a polyurethane foam slab (no frame)
2	Desk	4 x 2 x 3
Front room (8 x 12)		
2	Chair	2.5 x 2.5 x 2

3.5 Design Testing

Students are encouraged to test components of the design prior to the final burn day to confirm system(s) perform as proposed. This could include testing of individual components or full systems. Please be sure to test components of your design in methods not involving active fire unless you are in the appropriate laboratory with the appropriate personnel to conduct an active fire test.

The use of Arduino microprocessors and/or sensors, or similar, are encouraged. These can be used to act as a notification system once the fire is detected or as part of the suppression design. The Arduino programming software is available free online. If a team chooses to utilize an arduino, thresholds and limitations exist. Your teacher can access helpful tools for arduino programming code in the "Fire Protection Engineering Design Challenge: School Resources" shared google drive.

3.6 Restrictions

1. No design may include any explosive item.
2. Power sources should be external to the model structure.
3. Any batteries used in the design must be placed at a location outside the structure, other than on the roof.