

Spring 2009  
Waterloo Engineering Competition  
June 22 – 27

**Senior Team Design  
Competition Problem**



**GENERAL RULES**

1. All questions regarding the competition problem must be asked during the welcome and briefing session. No questions will be answered during the design and build stage.
2. Teams are not allowed to leave the DWE and RCH buildings unless they have submitted their prototypes and presentations to competition staff.
3. All communication devices must be turned off throughout the entire duration of the competition.
4. Wireless on laptops must be turned off. Violation of this rule will result in immediate disqualification.
5. Visitors are not allowed throughout the design and build stage. Violation of this rule will result in immediate disqualification.
6. Teams may only use materials they have purchased in the shop.
7. Final prototype and presentation materials must be submitted to the submission desk prior to the end of the design and build stage. It is the team’s responsibility to bring its deliverables from the design area to the submission desk.
8. Competitors may not use the blackboard when delivering presentations.
9. Keep work spaces clean. Tidy up at the end.

**SCHEDULE**

The schedule of the Junior Team Design competition is as follows:

Friday, June 26	5:45 p.m. – 6:00 p.m.	Sign-In	RCH 101
	6:00 p.m. – 6:30 p.m.	Welcome/Briefing	RCH 101
	6:30 p.m. – 12:30 a.m.	Design/Build	Various Assigned Classrooms
Saturday, June 27	8:45 a.m. – 9:00 a.m.	Sign-In	RCH 301
	9:00 a.m. – 12:30 p.m.	Presentation/Demonstration	RCH 301

Drinks will be available throughout the development and build stage of the competition. Volunteers will bring pizzas around to teams between 8:30 and 9:00 p.m. Please remind the competition coordinators and volunteers of your dietary restrictions and/or allergies.

Dress code for presentation and demonstration is business casual (dress shirt and dress pants).

There will be a question period after the problem is presented. No questions will be answered during the development and build stage to ensure fairness in the competition.

## **THEME**

The theme of the Spring 2009 Senior Team Design is *“alleviating natural disasters.”*

## **SCENARIO**

Forest fires are a common occurrence, especially in regions with drought seasons. Firefighting can be a dangerous job. To reduce work-related injuries and deaths, the government has contracted your company to design a remote controlled fire truck.

This fire truck shall be able to carry water into the forest and put out wild fires. The vehicle must be able to travel through uneven terrain. In the case of obstacles, the vehicle can either push the object if small, or navigate around the obstacle. According to the geographic data that your company has been provided, a trail weaves through the wooded area. Fire locations are not necessarily right beside the trail. There is a small lake in the area and a few other puddles, which may or may not be dried up depending on the time of year.

## **OBJECTIVE, REQUIREMENTS & CONSTRAINTS**

Design a fire truck remotely controlled through minimum two (2) metres of cable using only the materials provided. The fire truck must be able to navigate the given terrain in the above scenario and put out four individual candles of various heights, as tall as 30 cm, and a small field (approximately 100 cm<sup>2</sup>) of candles, tall or short. The vehicle must not exceed 20 cm x 20 cm x 17 cm (L x W x H) in dimension, and should carry sufficient water to put out all the fire in one run. Fire can only be extinguished using water. If the vehicle runs out of water during demonstration, more water can be added but there will be penalty in the marking scheme. The trail will be covered with sand.

The remote control and the attached cable must not have direct physical impact on the fire truck, i.e. steering by pulling the vehicle is not allowed. Only one person is allow to operate on the remote control at any time; another person can hold up the cable to prevent physical interference. Teams are not permitted to touch the vehicle during demonstration. The cost of the design prototype may not exceed \$10,000.

## **PROTOTYPE TESTING RULES**

A portion of the terrain will be available for teams to perform prototype testing. Each testing period is 10 minutes, and is signed-up for on a first-come-first-serve basis.

### **Reservations**

Each team may only have one reservation at any time, and must use up the testing period before reserving the next one. Teams may only reserve whichever time slot is available next (i.e. teams may not specify a time).

### **Cancellations**

Teams are allowed to make cancellations to reservations. A cancelled time slot then becomes the next available testing period, and can be reserved by whichever team makes the reservation next. Time slots after the cancellation will not be bumped up.

### **Consumable Items**

Some items are consumable, for example: batteries. Teams are responsible for these consumable items for presentation and demonstration.

## SHOP RULES

1. A maximum of two (2) people per team may be in the shop at any time.
2. When purchasing, a team member must bring the Purchase Requisition Form.
3. All sales are final. Be sure to verify purchased items and quantities before leaving the shop.
4. Teams may not trade building materials. Violation of this rule will result in immediate disqualification for both teams.
5. When there is a discrepancy between a team's Purchase Requisition Form and the shop records in either the type or quantity of purchased items, the team's Purchase Requisition Form will take precedence. (For example: if your Purchase Requisition Form indicates you have purchased three mousetraps and the shop records indicates otherwise, the shop records will be corrected to three mousetraps.)
6. When there is a discrepancy between a team's Purchase Requisition Form and the List of Materials in the unit price, the WEC reserves the right to make corrections on the team's Purchase Requisition Form.
7. The shop will close 30 minutes before the development and build stage ends.

## BUILDING MATERIALS

Building materials will be available, while quantities last, for teams to build prototypes. Teams may use only the materials listed in the List of Materials.

### List of Materials

Item	Unit Price
<b>General</b>	
Mousetrap	\$200
Foam board (19.5 cm x 13.5 cm)	\$1800
Foam board (19.5 cm x 10.5 cm)	\$1600
Foam board (custom size)	\$11/cm <sup>2</sup>
Wooden board (20 cm x 15 cm)	\$800
Wooden board (custom size)	\$7/cm <sup>2</sup>
Cardboard (27 cm x 16 cm)	\$1275
Cardboard (27 cm x 10 cm)	\$1125
Cardboard (19.5 cm x 16 cm)	\$1200
Cardboard (19.5 cm x 10 cm)	\$1050
Large dowel (30.5 cm x $\varnothing$ 1.1 cm)	\$300
Medium dowel (30.5 cm x $\varnothing$ 0.9 cm)	\$280
Small dowel (30.5 cm x $\varnothing$ 0.4 cm)	\$200
Popsicle stick	\$60
Nail	\$20
Paper clip	\$10
Toothpick	\$4
CD	\$190
Styrofoam ball ( $\varnothing$ 6.5 cm)	\$270
Plastic wheel ( $\varnothing$ 4.8 cm)	\$320
Tube w/ foam padding (7.7 cm x $\varnothing$ 6 cm)	\$400
Pipe cleaner	\$50
Plastic straw	\$50

Steel wire 20 AWG (no insulation)	\$4/cm
Rope ( $\varnothing$ 3 mm)	\$10/cm
Utility cord ( $\varnothing$ 4 mm)	\$12/cm
Cotton twine	\$3/cm
Plastic spoon	\$50
Plastic plate	\$280
Plastic cup	\$300
Pot pie pan	\$350
Muffin cup	\$20
Aluminum foil	\$20/cm
Saran wrap	\$15/cm
Sand paper	\$50/cm
Paper towel	\$30/segment
Large zip tie (20 cm x 0.5 cm)	\$70
Medium zip tie (15 cm x 0.4 cm)	\$60
Small zip tie (10 cm x 0.3 cm)	\$40
Elastic band	\$40
<b>Adhesives</b>	
Clear packing tape	\$4/cm
Masking tape	\$2/cm
Double-sided foam tape	\$15/cm
Super glue	\$100
Glue gun	Free
White glue	Free
<b>Electrical</b>	
Motor RF-500TB	\$850
Motor RE-140RA	\$850
Motor 169324	\$950
Motor 9167AJ	\$950
ON/OFF/ON toggle switch	\$150

Battery holder 4-AA cells	\$20
Battery holder 8-AA cells	\$35
AA Battery	\$17
Stranded wire 22 AWG	\$1/10cm
Solder	Free

### DC Motor Specifications

Choosing the right motor is extremely important for a successful engineering design. Four DC motors have been selected for this competition, and are listed below in order of rotation speed. Relevant specifications have been

Part Number	Voltage (V)		No Load		Stall
	Operating Range	Nominal	Speed (r/min)	Current (A)	Current (A)
RF-500TB	1.5 – 12	6.0	2,700	0.020	0.35
RE-140RA	1.5 – 3.0	1.5	8,100	0.210	2.1
169324	6.0 – 12	12.0	10,000	1.400	72.0
9167AJ	6.0 – 24	24.0	14,000	0.600	32.0

Be sure to do a sanity check before leaving the shop with the motors to avoid faulty parts.







## **DELIVERABLES**

At the end of the six- (6) hour development and build stage, each team is required to submit the following items:

1. A working prototype of the machine
2. A PowerPoint presentation
3. Purchase Requisition Form (both sheets)

**MARKING SCHEME**

The following marking scheme is specific to the Spring 2009 Senior Team Design competition and will be used by judges during presentation and demonstration.

<b>Design &amp; Performance</b>	<b>60%</b>
Put out candle #1	10%
Put out candle #2	10%
Put out candle #3	12%
Put out candle #4	12%
Put out candle field	16%
Finish early	+ 15% per minute*
Put out candle field within 10 seconds	+ 5%
Not able to move at all†	- 60%
Get stuck in terrain	- 10% each time*
Slide off track	- 7%
Refill vehicle with water	- 2% per refill*
<b>Presentation</b>	<b>25%</b>
Design Process	6%
Meet Constraints & Criteria	6%
Quality & Flow	6%
Highlights & Usability	5%
Prototype Critique	2%
Cost below \$2500	+ 2%*
Cost over \$8500	- 2%*
<b>Originality</b>	<b>10%</b>
Daring/Outside the Box	4%
Creativity	3%
Uniqueness	3%

<b>Teamwork</b>	<b>5%</b>
Knowledge	2%
Workload Distribution	2%
Compatibility	1%
Positivity	+ 1%*
Follow Dress Code	+ 1%*
<b>TOTAL</b>	<b>100%</b>

In case of a tie in total marks, the teams will be ranked based on their points scored in Design & Performance.

Completed marking sheets will not be disclosed to competitors; however, if teams wish to know their strengths and weaknesses for improvement in future competitions, judges will be available after the competition for questions.

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\* The  $\pm$  signs denote bonus or penalty points, respectively. Lowest possible score for each marking category is zero (0) points.

† The WEC marking scheme explicitly states that a vehicle not being able to move constitutes as a design fail. Be sure to keep this in mind when competing at the OEC, as the same rule applies but is not stated in the marking scheme.