Tideway

Science Maths

CREST Silver Award

TUNNELWORKS
CREST INTRODUCTION FOR TEACHERS

Tunnelworks includes ideas for student projects that can lead to a CREST Award.

About the Thames Tideway Tunnel

39 million tonnes of untreated sewage overflows into the River Thames each year from London's Victorian sewerage system. The Thames Tideway Tunnel is a major new sewer that will tackle this problem, protect the River Thames from increasing pollution for at least the next 100 years, and enable the UK to meet European environmental standards.

Find out more about the Thames Tideway Tunnel here: **http://www.thamestidewaytunnel.co.uk/**

What is CREST?

CREST is a project-based awards scheme for the STEM subjects (Science, Technology, Engineering and Maths), managed by the British Science Association. It links the personal passions of students aged 11-19 to curriculum based learning.

UCAS endorse CREST Awards for inclusion in students' personal statements – they're well regarded, high quality and a tangible recognition of success.

Find out more at: **http://www.britishscienceassociation.org/crest**

What can my students do?

There are CREST projects that build on Tunnelworks across all three levels; Bronze, Silver and Gold.

Bronze Awards focus on fun, teamwork and transferable skills. They are typically completed by 11-14 year olds; around 10 hours of project work is expected from each student. Students experience the project process, improving their enquiry, problem solving and communication skills.

Silver Awards stretch students and enrich their studies. They are typically completed by 14-16 year olds; around 30 hours of project work is expected from each student.

How do I get started?

Awards are organised and administered through a network of Local Coordinators. You can find your Local Coordinator by visiting the contacts page on the CREST website, above. They'll help you register and provide expert guidance throughout the scheme.

How should students tackle a project once I've registered them?

Use the Thames Tideway Tunnel web link above to make sure that students are aware of the background to their project.

Students can work alone or in a team of 2-4 students to complete their project. Students can share the work in their teams and split into pairs or individuals to complete parts of it, coming together to share and combine their work. **However, every student needs to complete the minimum time and meet the requirements of the award.**

Your Local Coordinator will guide you through the process and will show you what's expected of each student, including the minimum time they should spend working on their project, how they should plan and document their work and the award requirements at Bronze and Silver level.

How are projects assessed?

To gain their CREST awards students must spend a sufficient amount of time on their project and produce original work at an appropriate intellectual level. The requirements at Bronze and Silver level are laid out clearly in the CREST Award Requirements PDF which you can access via this link to the CREST website: ***http://www.britishscienceassociation.org/crest-awards***

The teacher usually assesses Bronze awards while Silver awards are assessed externally. Your CREST Local Coordinator will be happy to advise you on Bronze assessment, especially if you are new to the scheme.

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CREST Silver Award

Fresh air under London

CREST Silver Design/Engineering Project Student Brief

What's the background?

Increasingly, when it rains in London there is not enough capacity in London's Victorian sewerage system to convey all the rainwater, as well as foul water, from homes and businesses. The Thames Tideway Tunnel is a major new sewer that will tackle this problem and protect the River Thames from increasing pollution for at least the next 100 years. To meet strict environmental standards for air emissions from the Tunnel, a ventilation system will exchange the air in the Tunnel at least once every 24 hours.

What systems and choices are needed to create an effective, efficient ventilation system?

Your design/engineering challenge:

Research and design a fan system to maintain a constant airflow through a pipe at least 10cm diameter and 4m long, at minimal energy input, fully exchanging the air in the pipe at least once every 10 seconds. Include a control and warning system that lets you vary the output of each fan and which warns of a fault.

Some things to think about…

- What air speed you will need to create
- How you will research and identify the most efficient blade designs and configurations and motors to use
- How you will investigate the most efficient placement of your fan(s)
- How you will control each fan and warn of a fault
- How you will measure the energy efficiency of your system and ensure it is maximised
- How best to capture and present your test and operating data
- List any websites you use in an appendix, and show in your report where you have used each source of information in your report.

Health and Safety

Before you carry out any experiment:
(a) find out if any of the substances, equipment or procedures are hazardous
(b) assess the risks (think about what could go wrong and how serious it might be)
(c) decide what you need to do to reduce any risks (such as wearing personal protective equipment, knowing how to deal with emergencies and so on)
(d) make sure your teacher agrees with your plan and risk assessment
NOTE: Your teacher will check your risk assessment against that of your school. If no risk assessment exists for the activity, your teacher may need to obtain special advice. This may take some time.
(e) if special tools or machines are needed, arrange to use them in a properly supervised D&T workshop.

Fresh air under London

CREST Silver Design/Engineering Project Teachers

The Tunnelworks CREST Introduction for Teachers provides important information you will need alongside this document.

Design/Engineering focus

Students should research and design a fan system to maintain a constant airflow through a pipe at least 10cm diameter and 4m long, at minimal energy input, fully exchanging the air in the pipe at least once every 10 seconds. They must include a control and warning system that lets them vary the output of each fan and which warns of a fault.

Possible equipment, materials and resources

- Suitable piping at least 10cm x 4m, such as carpet tube, drainpipe
- A variety of motors and blades that will fit in the pipe
- Materials to create supports for the motors and blades
- Electrical/electronic components to create a control and warning system
- Multimeters/volt and ammeters/data logging sensors and software
- Hand-held anemometer or other apparatus to measure air flow

Prompts

The student brief gives ideas to start students' thinking. Each one implies several items to research and students should identify these themselves. If necessary, use the prompts below to point students in suitable directions.

- How will students measure airflow?
- What parameters will help students identify the most efficient motor and blade combination?
- How can students measure air speed in the pipe to identify maximum distance between fans?
- What circuits will allow individual control of each fan?
- How can students detect and warn of a fault?
- What measurements are needed to calculate energy use?

Suggestions for supporting students

Although primarily a practical challenge, students may need to research what equipment they will need for their system and to gather data. Students may need some direction from you to identify suitable sources of relevant information at an appropriate level, and to ensure that their practical procedures are appropriate, feasible and safe.

It is recommended that, wherever possible, Silver Award students should have a scientist or engineer as Mentor for their project. Please contact your CREST Local Coordinator to discuss Mentoring. Depending upon the nature of the project, someone with knowledge and/or experience

of electronics or aeromodelling could be ideal.

If you live in Southwark, Wandsworth, Hammersmith and Fulham, Newham or Greenwich, you may be able to access a Thames Tideway Tunnel STEM ambassador who can help. Please contact ***education@tidewaytunnels.co.uk***.

Discuss with students how they will manage their time (after school clubs, working during lunch hours, homework). Agree a completion date with them.

Internet search

Try: RC propeller, RC gearbox, anemometer, motor speed control.

CREST Silver Design/Engineering Project
Student Brief

What's the background?

Increasingly, when it rains in London there is not enough capacity in London's Victorian sewerage system to convey all the rainwater as well as foul water from homes and businesses. The Thames Tideway Tunnel is a major new sewer that will tackle this problem and protect the River Thames from increasing pollution for at least the next 100 years. To ensure safe and effective operation the Tunnel must be regularly inspected to identify obstructions or areas requiring maintenance. How can Thames Water ensure the 7.2m diameter Tunnel is structurally sound and free from obstructions?

Your design/engineering challenge:

Research, design and build a prototype or proof of concept demonstration for an autonomous Tunnel Inspector. Your design must be autonomous, able to navigate around small obstructions (20 x 20cm), cope with wet conditions and capture image and location/distance travelled data (accurate to 0.5m) while deep underground.

Some things to think about…

- The Tunnel has a diameter of 7.2m. What size and shape will your Inspector be?
- How will the Inspector propel and steer itself to maintain course and avoid obstructions?
- What sensors and processing will the Inspector use to detect and avoid obstructions and continue on its journey along the Tunnel?
- How will the Inspector gather and store location / distance data?
- How will the Inspector capture and storage images of the whole Tunnel around it?
- What design strategies will protect the Inspector from water and debris?
- List any websites you use in an appendix, and show in your report where you have used each source of information in your report.

Health and Safety

Before you carry out any experiment:
(a) find out if any of the substances, equipment or procedures are hazardous
(b) assess the risks (think about what could go wrong and how serious it might be)
(c) decide what you need to do to reduce any risks (such as wearing personal protective equipment, knowing how to deal with emergencies and so on)
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Possible equipment, materials and resources

- Internet access for research
- STAMP, PIC or Arduino microcontrollers, motor/sensor interfaces and programming software
- Compatible sensor modules, eg distance, touch
- Electrical and mechanical parts for wheeled or tracked vehicle design, such as stepper motors, wheels, tracks, axles, gearboxes etc.

Prompts

The student brief gives ideas to start students' thinking. Each one implies several items to research and students should identify these themselves. If necessary, use the prompts below to point students in suitable directions.

- What speed would their Inspector need to travel at?
- How can an autonomous vehicle keep a straight course in a circular tunnel?
- What minimum information is needed to know location in a straight tunnel?
- Where would an obstruction lie in a circular tunnel?
- How can a vehicle sense an obstruction?
- What general course would allow a vehicle to get round an obstruction?
- Where might water and dust enter a vehicle?
- How can the operator link an image to where it was captured?

Suggestions for supporting students

Although primarily a practical challenge, students may need to research what equipment they will need for their system and to gather data. Students may need some direction from you to identify suitable sources of relevant information at an appropriate level, and to ensure that their practical procedures are appropriate, feasible and safe.

It is recommended that, wherever possible, Silver Award students should have a scientist or engineer as Mentor for their project. Please contact your CREST Local Coordinator to discuss Mentoring. Depending upon the nature of the project, someone with knowledge and/or experience of robotics or autonomous vehicle design could be ideal.

If you live in Southwark, Wandsworth, Hammersmith and Fulham, Newham or Greenwich, you may be able to access a Thames Tideway Tunnel STEM ambassador who can help. Contact ***education@tidewaytunnels.co.uk***.

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Internet search

Try: autonomous vehicle, PIC robot, PICAXE robot, ARDUINO robot.