Imperial College London

RISK ASSESSMENT AND STANDARD OPERATING PROCEDURE FOR FIRST YEAR UNDERGRADUATE PROJECTS

1. PERSON(S) CARRYING OUT THIS ASSESSMENT – The assessment should be carried out as a joint exercise between the student(s) and the supervisor.	
Name (Demonstrator/Supervisor)	Kenneth Long
Name (Student)	Hiroki Kozuki, Yaar Safra, Daniel Somerville Roberts, Thomas Stuart – Smith
Name (Student)	
Date	25/05/2022

2. PROJECT DETAILS – Delete building as applicable. You can fill in the room location once you know exactly where your project will be based.					
Project Name	Investigating the Properties of electrons from Thermionic emission			Project Code	P3N
Brief Description Of Project Outline	Investigate the velocity distribution of electrons produced via thermionic emission at varying temperatures/power. A cathode (thoriated tungsten) will be directly heated to trigger thermionic emission. Electrons are emitted with a range of velocities and will be deflected by a Wien filter. A sliding faraday cup will be used to measure current densities as different velocities will be separated by the Wien filter. From this, we aim to plot the velocity distribution of emitted electrons (velocity vs. current density). The distribution plot will be produced for varying input power and temperature of the cathode, and we aim to reach a conclusion that elaborates on their relationship.				
Location	Campus	South Ken	Building	Blackett	Room: 1st Year Labs

3. HAZARD SUMMARY – Think carefully about all aspects of your project and what your work could entail. Write down any potential hazards you can think of under each section – this will aid you in the next section. If a hazard does not apply then leave blank.			
Manual Handling	Careless handling of components when moving and calibrating may cause them to break or inflict damage on the handler. These components include the vacuum chamber, high voltage power supply, chemical compounds in the cathode, and hot wires.	Electrical	High voltage (2~3 kV) AC/DC power supply used. May cause electric shocks. Plasma may form inside the vacuum chamber at high voltages since we cannot have a perfect vacuum. The probabilities of the accelerated electrons penetrating the glass chamber wall or producing secondary electrons are negligibly low due to the stopping power of the glass ($60{\sim}70\ MeV\ cm^2\ g^{-1}$) associated with its thickness ($5{\sim}10\ mm$ thickness with density of roughly $2.70\ g\ cm^{-3}$ giving $1.35{\sim}2.70\ g$ per $1\ cm^{-2}$ cross section. Hence stopping power across glass wall

			thickness is $81 \sim 189\ MeV$). This value is significantly greater than the expected energy of the emitted electrons ($\ll 1\ KeV$). <u>Source:</u> https://physics.nist.gov/PhysRefData/Star/Text/ESTAR.html
Mechanical	N/A]	Hazardous Substances	Nickel oxide is carcinogenic when inhaled. May cause allergic skin reactions and respiratory problems. Barium oxide is toxic if swallowed, harmful when inhaled, and causes severe skin irritation and eye damage upon direct contact. Likewise, thorium oxide is mildly radioactive and overall harmful. Eating and drinking in the lab may cause poisoning.
Lasers	N/A]	Noise	Accidental implosion of the vacuum chamber would generate considerable sound. Noise produced by high voltage AC/DC power supply may cause minor inconveniences such as making voices hard to hear.
Extreme Temperature	Cathode (tungsten or nichrome) will be heated to high temperature. May overheat and damage components, as well as inflict burns if not careful. As a part of making our own equipment, we will need to **solder** metals together. For associated hazard risks and mitigations/solutions, refer to SOLDERING.pdf	Pressure/Steam	Vacuum chamber with fractures may implode. May cause glass splinters and cuts. Severe damage may be dealt in the worst-case scenario.
Trip Hazards	Potential risk of tripping over bags, as well as wires and cables connecting power supply to outlet.	Working At Height	Vacuum chamber may fall off the work-table if unstable or while carrying if there are any trip hazards.
Falling Objects	Vacuum chamber may fall off the work-table if unstable or while carrying if there are any trip hazards.	Accessibility	Vacuum chamber will be sealed off and any accidents that happen inside cannot be dealt with until chamber interior is pressurised to STP.
Other			

4. CONTROLS – List the multiple procedures which you may carry out during your project along with the controls/ precautions that you will use to minimise any risks. Remember to take into consideration who may be harmed and how – other people such as students, support staff, cleaners etc will be walking past your experimental setup even when you aren't around.	
Brief description of the procedure and the associated hazards	**Controls to reduce the risk as much as possible**
1. Setting up the vacuum chamber using a vacuum pump. Accidental fractures in the vacuum chamber may cause implosion due to pressure differential. Associated hazards are glass splinters (with risks of skin, eye, and respiratory damage) and exposure to harmful material inside the chamber (e.g., high voltage discharging plates, hot cathode, and carcinogenic Nickel/Barium oxides). Unstable positioning of the chamber may cause in to fall and break. People at risk are anyone within the range of flying glass. 2. Providing power to the cathode via high voltage AC supply (2~3 kV). Unsecured connections and loose wires may cause electric shocks and sparks. Too high a voltage may also create plasma inside the vacuum chamber, which may damage components inside the chamber, as well as impose risk of accidents such as implosion. People at risk are anyone near the circuit where high voltage is set up. Overloading may melt the nickel oxide cathode, which may damage the set-up and potentially inflict burn on anyone who touches the cathode before letting it cool. 3. Potentially coating the tungsten/nickel oxide cathode with thorium oxide or barium oxide and heating it to high temperature suitable for thermionic emission. Oxides of nickel, thorium, and barium are irritating to the skin and will cause severe damage if it gets into the eye. Inhaling these powders may result in respiratory problems They are also carcinogenic. People at risk are anyone that touches these substances and those within the range where the powder could reach by air current. 4. Wires and cables will be used to provide current to heat the cathode. Disorganized wires may become trip hazards which could lead to more severe accidents such as dropping and breaking the vacuum chamber and getting electrocuted/burnt. People at risk are anyone passing nearby the experimental set-up.	1. Discuss with lab technicians whether the proposed experiment is viable to conduct inside the vacuum chamber. The glass container will be examined beforehand for small faults and fractures. The vacuum chamber and other lab equipment will be placed on a spacious and sturdy base. Metallic or plastic shield shall be placed around the chamber to block flying glass in case it implodes. Wear protective gears including safety goggles, lab coats, and gloves. Avoid wearing open shoes, short sleeves, and short pants. Follow the lab protocol as instructed by lab technicians. 2. Current will be kept small such that accidental electrocution will not result in severe injury (we will decide on the range of operating current and voltage with the supervisor and lab technicians to keep them low enough to prevent plasma forming.) Voltage will be raised gradually to preserve the lifetime of the cathode as well as to avoid sudden surge in power input. Rubber gloves may be worn to diminish electric shock and prevent severe burns if anyone touches the hot cathode (we will generally not touch it until it cools down to roughly room temperature.). 3. We will thoroughly examine with our supervisor and lab technicians the feasibility of coating/doping the cathode with barium oxide safely. The substance will be stored in a well-sealed container with sufficient thickness to block small amounts of radiation emitted by barium oxide. Safety goggles, gloves, lab coats, and masks will be worn when dealing with barium oxide powder. We will ensure not to spill any of these chemicals during transportation and set-up. 4. Wires will be bundled and kept away from pathways. 5. Bags will generally be left in the lockers or safely put away under the worktable where they would not obstruct people traversing the lab. 6. General care will be taken in moving lab

5. Bags may become trip hazards if not properly put away under the table or if placed in the open. Tripping on bags could lead to broken instruments and injury. People at risk are anyone walking near the bags. 6. Fragile pieces of equipment may be damaged during transport and calibration and may result in injuries from glass pieces, electric shocks, and implosion. 7. Soldering involved dealing with high temperature rods and melted metals, as well as harmful fumes. Consult SOLDERING.pdf for detailed risk assessment on soldering (including hazard risks and solutions).	equipment and calibrating them gently. We will conduct the experiment under supervision by each other and the lab technicians.

5. EMERGENCY ACTIONS – What to do in case of an emergency, for example, chemical spillages, pressure build up in a system, overheating in a system etc. Think ahead about what should be done in the worst case scenario.
In the case of emergency, turn off the power supply, undo the vacuum, and shut down the experiment. Evacuate the lab and call the lab technicians. If the situation is severe or a person is injured, call emergency service through Imperial's security office (4444 from internal phone or 020 7589 1000 form a mobile). More specifically, in the case of exposure to chemicals, rinse off the chemicals in the nearby sink or shower. If vacuum chamber is malfunctioning, pause the experiment and examine the container and the vacuum pump for faults. If an instrument brakes, call the lab technicians and order a replacement. Be ready to leave the lab anytime. Good communication among group members is essential.

6. TRAINING RECORD – As your project work evolves your experimental strategy/procedures may change. Therefore it is important that you review this risk assessment on a weekly basis and update it as necessary. Please sign and date below to indicate that all person(s) have been trained in this risk assessment and associated procedures.

Names (Supervisor + Students)	Sign	Date
Kenneth Long, Hiroki Kozuki, Yaar Safra, Daniel Somerville Roberts, Thomas Stuart-Smith		25/05/2022