

# APTITUDE EXAM

FOR SCHOLARSHIPS TO BE  
AWARDED IN SEPTEMBER 2023

**WEDNESDAY 1<sup>st</sup> FEBRUARY 2023 - AFTERNOON**  
**DURATION - 2 HOURS, 10 MINUTES**  
**(to include 10 minutes reading time)**

## INSTRUCTIONS TO CANDIDATES

You are required to answer **ONE** question from Section A  
and **ONE** question from Section B.

In **Section A** you are asked to provide **THREE** initial solutions to a problem.  
You will be marked on the following:

	<b>Mark</b>
a) <b>Quality</b> of your <b>THREE</b> solutions – how well you solve the problem along with the flair and imagination of your ideas.	30
b) <b>Technical knowledge</b> and the quality of your explanations.	15
<b>SECTION A TOTAL</b>	<b>45</b>

In **Section B** you are asked to solve a more focused problem, providing only **ONE** detailed solution.  
You will be marked on the following:

	<b>Mark</b>
a) How well your solution may <b>function</b> .	30
b) The <b>explanation of your solution</b> - your design decisions explained and justified.	15
<b>SECTION B TOTAL</b>	<b>45</b>

<b>Communication</b> including diagrams & designs, annotations and readability	<b>10</b>
<b>GRAND TOTAL</b>	<b><u>100</u></b>

**Please fill in the information box at the bottom of each answer sheet with:**

- ◆ Your candidate name and school name clearly printed on each sheet.
- ◆ Please circle the two numbers of the questions you have chosen to answer

**Please start each question on a fresh sheet of paper**

**Applicants must not discuss the exam on social media or in any other way**

**DO NOT TURN THE PAGE UNTIL YOU ARE INSTRUCTED TO DO SO**

## Section A – Suggested time 1 hour

### OPEN-ENDED QUESTIONS

In this section you will be assessed on your ability to solve the problem set in a **CREATIVE AND INNOVATIVE** way, by providing initial concepts.

Answer **ONE** question only from the following **THREE** questions.

Within your chosen question, you must provide three distinctly different solutions.

#### Question 1

Wheelchair users often find it difficult to participate in sports and hobbies.

Design three, easy-to-use accessories that clamp to a wheelchair, that will allow the user to take a more active part in three different activities.

The frame of the chair is made from 18mm diameter mild steel tube.

Whilst you should make it clear which part of the chair your devices clamp to you must focus on drawing the accessories and the method of attachment rather than the chair.



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#### Question 2

A paintball event company has introduced a new game for its participants.

When three different targets are hit bonus points can be scored.

Design three targets that, when hit, produce a unique and imaginative outcome: this could include the use of electronics and/or mechanical components.



Your answer should show clearly how these systems work.

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#### Question 3

A primary school wants to encourage their students to eat more fresh fruit at lunchtimes.

They are going to install a free-to-use machine in the dining hall that will dispense a single apple or orange on demand.

Produce three solutions which are fun and interactive and that use a variety of mechanisms to deliver the fruit.



You could consider integrating electronics to add to the appeal for the students. You could also include a creative way of starting or operating the machine.

**End of Section A**

## Section B – Suggested time 1 hour

### FOCUSED QUESTIONS

In this section you will be assessed on your ability to present ONE DETAILED TECHNICAL SOLUTION to the given problem focusing on functionality, components, materials and construction.

Answer ONE question only from the following THREE questions.

#### Question 4

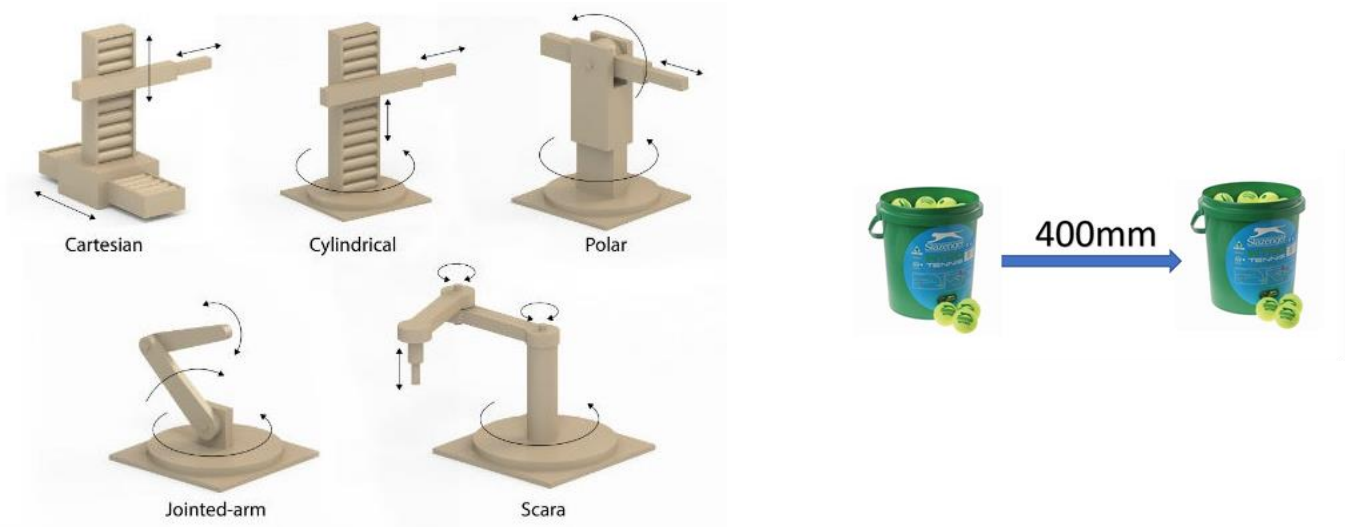
Design an electro-mechanical robotic 'claw grabber' to be used as an introduction to robotics by a school's STEM club.

As a challenge, students will use the 'claw grabber' to pick up individual tennis balls from a bucket and move them to another bucket 400mm away. The buckets are 300mm diameter at the top and 375mm high. A tennis ball is 68mm diam.

Some suggestions of types of robot are shown below.

You could use a different mechanism for each axis of movement. The 'claw grabber' must be operated by a simple wired electronic controller.

When designing your 'claw-grabber', you must explain clearly how each part of the machine and your chosen mechanisms works.



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#### Question 5

A manufacturer of toothbrushes wants to test the wear of the bristles on a new toothbrush design.

Design a test rig that can be used to simulate normal tooth brushing.

The user will manually load and unload the toothbrush, but otherwise the operation of the rig should be automatic.

The test rig is meant to simulate a year's use and then stop automatically.



## Question 6

Fences are often erected to separate boundaries. To construct these fences, posts are fixed into the ground at regular intervals. Marking out the positions of the posts for a long fence can take a long time so the process is being automated.

To do this a machine is needed, similar to the machine on the right, which is able to follow a pre-programmed path and spray a marker point on the ground with white paint to show where the posts will be located. The machine is battery powered.



This machine has the following input→process→output setup:

### Inputs

- Start button
- Wheel Sensor (1 pulse/m)
- GPS Sensor
- Obstacle avoidance sensor

### Process

- Controller chip

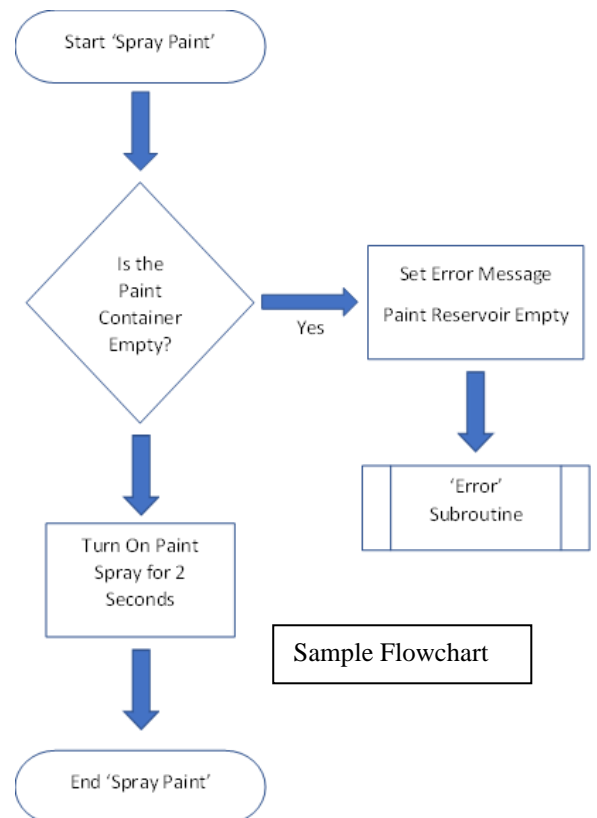
### Outputs

- Left motor
- Right motor
- Paint spray nozzle
- GPRS module (to send a text message if in trouble or to indicate the operation is complete)

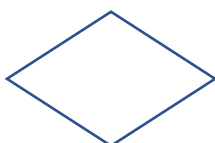
To help develop a coded solution you should **design the overall algorithms** with a flowchart which shows how the machine will start, follow a path (avoiding obstacles), spray paint markers and stop. Your flowchart should allow the machine to follow a pre-programmed path, spray a paint marker on the ground at 3m intervals and automatically shut down the machine at the end of the task. A sample flowchart to spray a marker point has been provided and may be referenced in your solution. Your answer should document the subroutine(s) needed to allow the machine to negotiate obstacles. You **do not** need to produce the coded solution.

You should include a start-up algorithm which will run through a series of self-checks that are required before the machine can start and use subroutines to perform specific tasks and to make the program easier to test and debug. You should **fully explain** each part of your design and avoid reference to specific software packages or hardware.

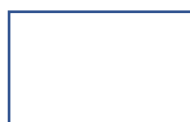
You should use the following flowchart symbols in your answer:



Terminator



Decision



Process



Subroutine



Input/Output



Flow

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