 Year 12 Mathematics Extension 1

Assessment task

MEX-V1 Introduction to vectors

Driving question

If you jumped on another planet, how far could you leap?

Outcomes

* **ME12-2** applies concepts and techniques involving vectors and projectiles to solve problems
* **ME12-6** chooses and uses appropriate technology to solve problems in a range of contexts
* **ME12 7** evaluates and justifies conclusions, communicating a position clearly in appropriate mathematical forms

All outcomes referred to in this unit come from [Mathematics Extension 1](https://educationstandards.nsw.edu.au/wps/portal/nesa/11-12/stage-6-learning-areas/stage-6-mathematics/mathematics-extension-1-2017) Syllabus © NSW Education Standards Authority (NESA) for and on behalf of the Crown in right of the State of New South Wales, 2017

Learning across the curriculum

General capabilities

* Critical and creative thinking
* Ethical understanding
* Information and communication technology capability
* Literacy
* Numeracy
* Work and enterprise

Context

Students are to investigate projectile motion and model a range of scenarios using vectors.

There are three key objectives for this task:

1. Students understand how to calculate the initial velocity of a projectile based on a launch angle and displacement.
2. Students understand how to predict the maximum height and range of a projectile with varying initial conditions
3. Students analyse the mathematical models to make inferences.

Background

During this task students will

* complete activities to develop initial conditions for a projectile modelling long jump
* derive equations of motion
* complete related calculations
* predict how far they could jump on other planets
* use graphing software to support their mathematical calculations.

Task

Part 1: shot put

When launching a shot put, the distance travelled is dependent on a range of variables; the launch angle, height and velocity.

The launch velocity is dependent on the angle of launch. An increase in the angle of launch decreases the launch velocity as a greater portion of the athlete’s muscular strength is used to overcome the gravitational force on the shot put, however, by increasing the launch angle the height of release is increased.

This can be observed diagrammatically in the graphs below.

Image of a scatterplot showing data for release height against Release angle from the journal of sports sciences, 2001. Image of a scatterplot showing data for release height against Release angle from the journal of sports sciences, 2001.

Source: Journal of Sports Sciences, 2001, 19, 359-372

shotputlinthorne.pdf document from the [elitetrack.com](https://elitetrack.com/articles/articles-read-2223/) website

From this activity students need to:

1. Select a release angle and use the graphs to obtain a release height and release speed.
2. Derive the horizontal and vertical equations of motion.
3. Determine the horizontal distance the shot put is thrown and the maximum height it reaches.
4. Determine the velocity of the shot put as it lands.

Part 2: Developing initial conditions

Students are to design and participate in a long jump activity where they complete multiple leaps and collect relevant data.

From this activity students need to:

1. Determine a typical launch angle using appropriate technology
2. Determine a typical length jumped
3. Explain how these were captured and the reasoning behind the choices made
4. Determine the initial vertical displacement of the model, comparing a range of possibilities and explain your choice.
5. Determine the initial velocity with appropriate mathematical calculations.

Part 3: Modelling a jump on other planets

Students are to choose **two** other planets. For each planet, students are to:

1. Record the initial conditions
2. Derive the horizontal and vertical equations of motion.
3. Determine the distance they could leap on two other planets.
4. Derive a Cartesian equation to represent the motion.
5. Use graphing software to confirm their results.

Note: Students can refer to [NASA’s factsheet](https://nssdc.gsfc.nasa.gov/planetary/factsheet/index.html) for appropriate gravity on other planets.

Part 4: Evaluation

Students need to evaluate their response to determine a position on the driving question, “If you jumped on another planet, how far could you leap?”

Students need to structure a response that refers to or considers:

1. The modelling and mathematical methods or concepts detailed in this assessment.
2. If there is a hypothetical maximum.
3. Any limitations to the model.

The final justification statement should answer the driving question by referencing the statements above.

What to submit

* Evidence of an authentic modelling. This may take the form of pictures of activities, screenshots of models with annotations.
* All data collected and initial conditions obtained.
* All formula, working and calculations required, either written by hand or typed. If screenshots have been provided, the formulas used need to be clearly annotated.
* All reasoning and justification, either written by hand or typed.

Success criteria

| Fluency, understanding and communication | Problem solving, reasoning and justification |
| --- | --- |

| Criteria | Working towards developing | Developing | Developed | Well developed | Highly developed |
| --- | --- | --- | --- | --- | --- |
| Part 1: Shot Put  **(ME12-2)** | Students are able to determine initial conditions. | Students are able to derive the horizontal and vertical equations of motion. | Students can apply the equations of motion to solve related problems. |  |  |
| Part 2: Developing initial conditions  **(ME12-2, ME12-6)** | Students are able to design an appropriate activity supported with appropriate technology. | Students are able to use their activity to determine the length jumped, launch angle. | Students can determine the initial velocity supported by mathematical calculations. | Students are able to explain their choices in regards to the design of the experiment and the initial vertical displacement. |  |
| Part 3: Modelling a jump on other planets  **(ME12-2, ME12-6)** | Students are able to determine initial conditions. | Students are able to derive the horizontal and vertical equations of motion. | Students can apply the equations of motion to solve related problems. | Students can derive a Cartesian equation to represent the motion and use graphing software to confirm their results. |  |
| Part 1: Evaluation  **(ME12-2, ME12-7)** |  | Students are able to state a response to the driving question. | Students are able to state a response to the driving question with reference to their mathematical model. | Students are able to explain a hypothetical maximum with reference to their mathematical model or limitations. | Students are able to take a position on and justify a hypothetical maximum with consideration to their mathematical model and limitations |

Note**s**

* Any non-attempt in a section will be deemed zero. Marks can only be attributed to attempted responses.
* Corresponding question numbers are shown in brackets.

Note to staff

The success criteria above has been designed for students and staff alike to use. Students should be presented the rubric as part of the assessment task package. Students and staff follow the process of the task downwards through the rubric and the depth of responses, for each element, across the rubric. Students should be encouraged to use the rubric to self-assess their progress as an assessment-as-learning strategy.

The aim of the assessment task is to develop students’ deep content knowledge. This is reflected in the descriptors, **working towards developing** through to **highly developed**. The level of skill and understanding required in each part of the task is different; some parts require **highly developed** or **well-developed** skills, other parts only capture a **developing** skill set.

None of the working mathematically elements are distinct and when demonstrating one element, you are invariably demonstrating another. As an example, communication runs concurrently through all the other working mathematically elements. Students cannot respond to this assessment without communicating in some form. However, it is envisaged that there is a general progression through the working mathematically elements, starting with fluency and leading to understanding, problem solving, reasoning and justification, with increasingly higher levels of communication accompanying each element. Careful consideration has been given to the position of the success criteria statements so they reflect the working mathematically elements demonstrated.

This assessment task has been designed to illuminate the style of questions and the types of responses needed to elicit deep content knowledge, however, staff are encouraged to use and adapt the assessment task and the success criteria to their school context. Staff may like to enhance or amend sections of the task. Staff may like to adapt the rubric to assign marks to the descriptors in order to differentiate between responses that address the same statement. All changes are the responsibility of the staff using the assessment.