Teachers’ manual  
Free-body box

# Introduction

A 3D-printed free-body box with arrows is used to help students visualize the free body diagram for different simple mechanical systems.

# Related Concepts

Vectors, Force, Free-body diagram

# Objective

* To visualize the free body diagram in different simple mechanics systems
* To clarify the directions and the points of application of different forces acting on an object

# materials

|  |  |
| --- | --- |
| Item | Quantity |
| Free-body box | 2 |
| Ramp | 2 |
| Pulley | 1 |
| String/rope | adequate |

# Preparation

## Materials needed

|  |  |
| --- | --- |
| **Item** | **Quantity** |
| 3D printer and raw material | 1 |
| Colour Marker | 1 |
| String | adequate |
| Reusable Adhesive  (e.g. Blu-tack, Hoop & Loop fastening tape) | adequate |

## 3D printed materials

|  |  |
| --- | --- |
| **Item** | **Quantity** |
| The block | 1 |
| Arrow   * Force * Friction * Normal force * Tension * Weight | 1 for each |

## Procedure

*3D printing*

1. Download the .stl file..
2. Import the .stl file to the 3D printer for printing.
3. Select the parameters of 3D printing based on the printer availability.
4. Print all the materials.

(The quality of the 3D printing models depends on the 3D printer quality and settings)

*Making of the arrows*

* “External force”: stick the reusable adhesive both ends of the arrow.
* “Friction”: stick the reusable adhesive at the end of the arrow.
* “Normal force”: stick the reusable adhesive at the end of the arrow.
* “Weight”: Use a small string to tighten the arrow loosely to the hole at the centre of the block.

# suggested demonstration

1. Give a brief summary about different types of force, how and when does the force occur.
2. Check students’ prior knowledge on free-body diagram and consolidate their ideas by providing clear guidelines on how to draw the diagram (Worksheet P.1).
3. Allow students to discuss with others to try the prediction in the worksheet (Worksheet P.2).
4. Carry on the session depends on teacher’s choice

Teacher perform the demonstration

* 1. Put all set up on a table and set up as the cases shown in the worksheet.
  2. Demonstrate or ask students to put all the force arrows on the block appropriately.
  3. Tackling any misconceptions, e.g. misplacement of arrows, missed or excess arrows.
  4. Ask students to observe and draw the free-body diagram in the worksheet (Worksheet P.3).
  5. Repeat step a-d for the next case.

Students can have one set up per group

1. Allow students to work on different cases as shown in the worksheet.
2. Provided necessary guidance to the students in need.
3. Ask them to record their observation in the worksheet (Worksheet P.3).
4. Ask students to generalize the characteristic of common forces, draw and explain the examples on the worksheet (Worksheet P.4).
5. Solve students’ inquiries through discussion, explain and conclude the ideas.