

Free Body Diagrams and Newton's Second Law

Lesson 01 Student worksheet 45 minutes

Name: _____

Date: _____

Original classroom practice, not official IPC or SPC questions. Classroom record: **20 marks**, including the diagnostic check. This is not an examination grade. W1 is unscored. Homework and the optional extension are separate.

Use $G = mg$ for the gravitational force, where $g = 10 \text{ N kg}^{-1}$. Treat each object as a particle. Label each force with its name, magnitude and direction. State a positive direction before writing the force equation.

Q1 Quick diagnosis

4 marks

(a) A trolley moves to the right in a straight line at constant speed. What is its resultant force? Does zero resultant force mean an object must be stationary? Explain briefly. [2]

(b) A book rests on a table. A student calls the upward force of the table on the book and the downward gravitational force on the book a third-law pair. Explain the mistake. Identify the partner of the force of the table on the book. [2]

W1 A crate being pulled

Guided example — unscored

A 4.0 kg crate slides right on a horizontal floor. A horizontal rope pulls right with 14 N. Friction acts left with 6.0 N. There is no vertical acceleration. Find the acceleration.

Object: _____

Positive direction: _____

Draw a free-body diagram here. Then write the force equation and result.

Force equation: _____

Acceleration: _____

Q2 Changing the pull

6 marks

A 3.0 kg crate slides to the right on a horizontal floor. A horizontal rope pulls right with 15 N. Friction acts left with 6.0 N. There is no vertical acceleration.

(a) Draw and label all the forces acting on the crate. State the object represented by your diagram. [2]

(b) Choose a positive direction. Write a force equation and calculate the acceleration, including its direction. [2]

(c) The rope is released. Just after release, the crate is still moving right and friction is still 6.0 N to the left. Calculate the new acceleration. State whether the crate is speeding up or slowing down at this instant. Explain briefly. [2]

After feedback: explain one correction you made.

Q3 A suspended load

6 marks

A 4.0 kg load hangs from a vertical taut rope. At the instant considered, the load is moving upwards. The rope exerts an upward force of 32 N. The only other force on the load is gravity.

(a) Draw a free-body diagram for the load. Label both force magnitudes and directions. [2]

(b) Choose a positive direction. Write a force equation and calculate the acceleration, including its direction. [2]

(c) Is the load speeding up or slowing down at this instant? Explain using the directions of its velocity and acceleration. [2]

After feedback: explain one correction you made.

Q4 Exit ticket

4 marks

Name: _____

Complete independently.

A vertical rope supports a 2.0 kg parcel. At the instant considered, the parcel is moving downwards. The rope exerts an upward force of 24 N on the parcel. The only other force on the parcel is gravity.

(a) Draw and label a free-body diagram for the parcel. [1]

(b) Choose a positive direction. Use a force equation to calculate the parcel's acceleration, including its direction. [2]

(c) State the magnitude and direction of the force that the parcel exerts on the rope. [1]

Confidence: I can explain my model / I need help with one step

Step I would like to revisit: _____

Homework and optional extension

IPC homework

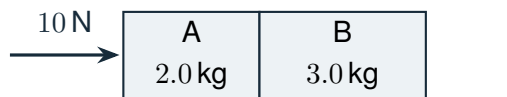
Complete *Intermediate Physics Challenge 2022*, **Question 5**, question-paper **page 4**. The paper specifies $g = 10 \text{ N kg}^{-1}$ on page 2. Choose the answer, then draw the rocket's free-body diagram and explain why engine thrust and resultant force differ.

The official multiple-choice question is worth **1 mark**. The diagram and explanation are additional teacher feedback tasks. This question is for teaching practice, not an unseen assessment.

SPC preparation Optional 6 separate marks

Original practice, not an official SPC question. Work **outside the lesson** for about 8–12 minutes. No calculus is needed.

Two blocks, A of mass 2.0 kg and B of mass 3.0 kg, touch on a horizontal frictionless surface. A is left of B. A horizontal external force of 10 N pushes A right. The blocks remain in contact and move together.



Trial 1: external force on A. Frictionless horizontal surface.

- (a) Treat A and B as one system. Find their acceleration. [2]
- (b) Consider B alone. Find the force on B from A. State its third-law partner, with magnitude and direction. [2]
- (c) In a separate trial, 10 N pushes B to the left. The blocks remain in contact. Find the contact-force magnitude. Explain why it can differ from (b) without violating Newton's third law. [2]

Continue on separate paper if needed. **Hint:** consider the block that has no direct external push.