

Show equations, substitutions, units, and vector directions. Explain your reasoning. Use sensible rounding.

Constants	$g_{\text{Earth}} = 9.8 \text{ m/s}^2$ $g_{\text{Moon}} = 1.6 \text{ m/s}^2$
Equations	$\Sigma F = F_{\text{net}} = ma$ $F_g = mg$ $1 \text{ N} = 1 \text{ kg}\cdot\text{m/s}^2$

Draw only forces acting ON the chosen object. State a positive direction.

2.1 Newton's First Law

1. A bus brakes suddenly. Explain why an unbelted passenger continues moving forward and how a seat belt changes the passenger's motion. Is inertia a force?

2. A crate slides east at constant velocity while a person pushes it east with 48 N. Find the friction force and net force. Explain why equilibrium does not require rest.

2.2 Types of Forces

3. For each interaction, name the force and classify it as contact or long-range: a cable supports a sign, water supports a boat, a floor supports a box, Earth pulls on a ball, air slows a falling leaf.

4. A sled slides east while a horizontal rope pulls it east. Name all four forces on the sled, their sources, and their directions. Ignore air resistance.

2.3 Free-Body Diagrams

5. Draw separate free-body diagrams for (a) a book at rest on a desk, (b) a puck sliding right and slowing down, and (c) an elevator speeding up while rising. Label forces and use relative arrow lengths.

(a) Book



(b) Puck



(c) Elevator



6. A 640 N skydiver falls straight down at constant speed. Draw and label the free-body diagram. Find the air-resistance force and acceleration.



2.4 Net Force

7. Two students push a cart east with 85 N and 65 N. Friction acts west with 110 N. Find the net force. If the cart is moving west, does it initially speed up or slow down?

8. A cable pulls upward on a 980 N load with 1176 N. Find the net force and predict the acceleration direction. Does this information alone tell you the velocity direction?

2.5 Newton's Second Law

9. A 12.0 kg box experiences a 72 N horizontal push right and 24 N friction left. Find its acceleration. What push would produce 5.0 m/s² right if friction stays 24 N?

10. A 6.0 kg cart accelerates at 3.0 m/s². Find the net force. Predict acceleration if (a) this force doubles or (b) the mass doubles while the original force stays constant.

2.6 Mass and Weight

11. An astronaut has a mass of 65 kg. Find her weight on Earth and on the Moon. State her mass on the Moon and explain the difference between mass and weight.

12. An object weighs 294 N on Earth. Find its mass. On another planet it weighs 111 N. Find the gravitational field strength there.

2.7 Newton's Third Law

13. A swimmer pushes water backward with 120 N. Identify the reaction force. Explain why the two forces do not cancel on the swimmer.

14. Two skaters of masses 40 kg and 60 kg push apart. Each experiences a 180 N force. Calculate each acceleration and compare the directions. Are the weight and normal force on one skater a third-law pair?

Unit 2 Review

15. A 20 kg crate starts from rest on a level floor. A horizontal 70 N pull acts right while 30 N friction acts left for 3.0 s. Find net force, acceleration, final velocity, and displacement.

16. Correct each claim: (a) Motion requires a net force. (b) A heavier stationary object has no inertia. (c) A scientific theory eventually becomes a law.