

SCI-223 TROY **Physical Science**
Chapter 1. Patterns of Motion and Equilibrium

Think and Solve (Mathematica Application)

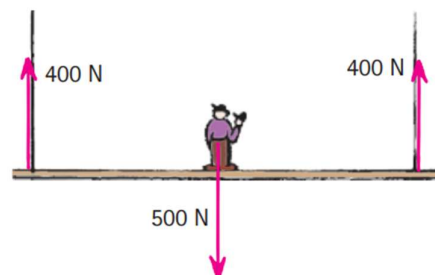
40. Find the strength of the net force produced by a 30-N force and a 20-N force in each of the following cases:

- (a) Both forces act in the same direction.
- (b) The two forces act in opposite directions.

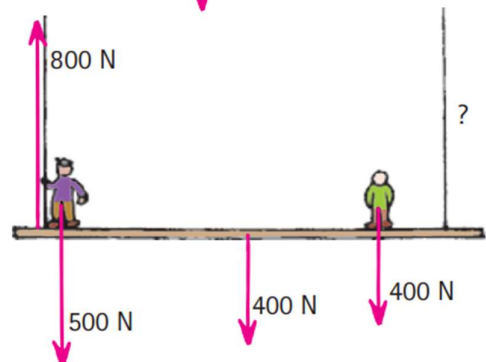
41. Lucy Lightfoot stands with one foot on one bathroom scale and her other foot on a second bathroom scale. Each scale reads 350 N. What is Lucy's weight?

42. Henry Heavyweight weighs 1200 N and stands on a pair of bathroom scales in such a way that one scale reads twice as much as the other. What are the scale readings?

43. The sketch shows a painter's scaffold in mechanical equilibrium. The person in the middle weighs 500 N, and the tension in each rope is 400 N. What is the weight of the scaffold?



44. A different scaffold that weighs 400 N supports two painters, one weighing 500 N and the other weighing 400 N. The reading in the left-hand scale is 800 N. What is the reading in the right-hand scale?



45. A horizontal force of 120 N is required to push a bookcase across a floor at a constant velocity.

- (a) What is the net force acting on the bookcase?
- (b) How much is the friction force that acts on the sliding bookcase?

(c) How much friction force acts on the bookcase when it is at rest on a horizontal surface without being pushed?

46. Driving along the road at 88 km/h, Reckless Rick runs into Hapless Harry, who is directly in front of him and is driving at 80 km/h. What is the impact speed—that is, the speed of the two vehicles the moment after collision?

47. An airplane with an airspeed of 90 km/h lands on a runway where the wind speed is 40 km/h. (a) What is the landing speed of the plane if the wind is head on?

(b) What is its landing speed if the wind is a tailwind, coming from behind the airplane?

(c) What would be the landing speed of the 90-km/h plane landing in a headwind of 90 km/h?

48. (a) Show that the average speed of a tennis ball is 48 m/s when it travels the full length of the court, 24 m, in 0.5 s.

(b) How would greater air resistance affect the travel time?

49. (a) Show that Leslie's average speed is 10 km/h when she runs to the store 5 km away in 30 min.

(b) How fast is this in units of m/s?

50. (a) Show that the acceleration is 7.5 m/s^2 for a ball that starts from rest, rolls down a ramp, and gains a speed of 30 m/s in 4 s .

(b) Would its acceleration be greater or less if the ramp were a bit less steep?

51. Lillian rides her bicycle along a straight road at an average velocity v .

(a) Write an equation showing the distance she travels in time t .

(b) If Lillian's average speed is 7.5 m/s for a time of 5.0 min , show that she travels a distance of 2250 m .

52. Extend Table 1.2 (which gives values from 0 to 5 s) from 6 s to 10 s , assuming no air resistance.

53. A car races on a circular track of radius R .

(a) Write an equation for the car's average speed when it travels a complete lap in time t .

(b) The radius of the track is 400 m , and the time to complete a lap is 40 s . Show that the average speed around the track is about 63 m/s .

54. A ball is thrown straight up with an initial speed of 30 m/s .

(a) How much time does it take for the ball to reach the top of its trajectory?

(b) Show that it will reach a height of 45 m (neglecting air resistance).

55. A ball is thrown straight up with enough speed so that it is in the air for several seconds.

- (a) What is the velocity of the ball when it reaches its highest point?
- (b) What is its velocity 1 s before it reaches its highest point?
- (c) What is the change in its velocity, Δv , during this 1-s interval?
- (d). What is its velocity 1 s after it reaches its highest point?
- (e) What is the change in its velocity, Δv , during this 1-s interval?
- (f) What is the change in its velocity, Δv , during the 2-s interval from 1 s before it reaches the highest point to 1 s after it reaches the highest point? (Caution: We are talking about velocity, not speed.)
- (g) What is the acceleration of the ball during any of these time intervals and at the moment the ball has zero velocity?

56. A school bus slows to a stop with an average acceleration of -2.0 m/s^2 . Show that it takes 5.0 s for the bus to slow from 10.0 m/s to a stop.

57. An airplane starting from rest at one end of a runway accelerates uniformly at 4.0 m/s^2 for 15 s before takeoff.

(a) What is its takeoff speed?

(b) Show that the plane travels along the runway a distance of 450 m before takeoff.

Readiness Assurance Test (RAT)

Choose the BEST way to complete the statement.

1. Science greatly advanced when Galileo favored
 - A. philosophical discussion over experiment.
 - B. experiment over philosophical discussion.
 - C. nonmathematical thinking.
 - D. none of these
2. According to Galileo, inertia is a
 - A. force like any other force.
 - B. special kind of force.
 - C. property of all matter.
 - D. concept opposite to force.
3. When a 10-kg block is simultaneously pushed eastward with a force of 20 N and westward with a force of 15 N, the combination of these forces on the block is
 - A. 35 N west.
 - B. 35 N east.
 - C. 5 N east
 - D. 5 N west.
4. Tension is actually a force that tends to
 - A. stretch something.
 - B. compress something.
 - C. break something.
 - D. balance something.
5. The equilibrium rule, $\Sigma F = 0$, applies to
 - A. objects or systems at rest.
 - B. objects or systems in uniform motion in a straight line.
 - C. both of these
 - D. neither of these
6. When you stand on two bathroom scales, one foot on each scale with weight evenly distributed, each scale will read
 - A. your weight.
 - B. half your weight.
 - C. zero.
 - D. more than half your weight, but less than your full weight.
7. Your average speed in skateboarding to your friend's house is 5 m/s. It is possible that your instantaneous speed at some point was
 - A. less than 5 m/s.
 - B. 5 m/s.
 - C. more than 5 m/s.
 - D. any of these
8. If an object moves with constant acceleration, its velocity must
 - A. be constant also.
 - B. change by the same amount each second.
 - C. change by varying amounts depending on its speed.
 - D. always decrease.
9. If a falling object gains 10 m/s each second it falls, its acceleration is

- A. 10 m/s. B. 10 m/s per second.
C. both of these D. neither of these
10. A freely falling object has a speed of 30 m/s at one instant. Exactly 1 s later its speed will be
A. the same. B. 35 m/s. C. more than 35 m/s. D. 60 m/s

1b 2c 3c 4a 5c 6b 7d 8b 9b 10c

Chapter 2. Newton's Laws of Motion

Think and Solve (Mathematica Application)

39. A Honda Civic hybrid weighs about 2900 pounds. Calculate the weight of the car in newtons and its mass in kilograms. (FYI, $0.22\text{ lb} = 1\text{ N}$; 1 kg on Earth's surface has a weight of 10 N .)

40. When two horizontal forces are exerted on the car in *Problem 39*, 220 N forward and 180 N backward, the car undergoes acceleration. What additional force is needed to produce non-accelerated motion?

41. A 120-kg astronaut recedes from her spacecraft by activating a small propulsion unit attached to her back. The force generated by a spurt from this device is 30 N . Show that her acceleration is 0.25 m/s^2 .

42. Madison pushes with a 160-N horizontal force on a 20-kg crate of coffee resting on a warehouse floor. The force of friction on the crate is 80 N . Show that the acceleration is 4.0 m/s^2 .

43. Sophia pushes with a 40-N horizontal force on a 4.0-kg box resting on a lab bench. The box slides against a horizontal friction force of 24 N . Show that the box accelerates at 4.0 m/s^2 .

44. A business jet of mass $30,000\text{ kg}$ takes off when the thrust for each of two engines is $30,000\text{ N}$. Show that its acceleration is 2 m/s^2 .

45. A rocket of mass $100,000\text{ kg}$ undergoes an acceleration of 2 m/s^2 . Show that the net force acting on it is $200,000\text{ N}$.

46. Calculate the horizontal force that must be applied to a 1-kg puck for it to accelerate on a horizontal friction-free air table with the same acceleration it would have if it were dropped and fell freely.

47. Leroy, who has a mass of 100 kg, is skateboarding at 9.0 m/s when he smacks into a brick wall and comes to a dead stop in 0.2 s.

(a) Show that his deceleration is 45 m/s^2 .

(b) Show that the force of impact is 4500 N.

48. For 3.0 s, Allison exerts a net force of 10.0 N on a 6.7-kg shopping cart that was initially at rest. Find the acceleration of the cart, and show that it moves a distance of 6.7 m.

49. The heavyweight boxing champion of the world punches a sheet of paper in midair, bringing it from rest up to a speed of 25.0 m/s in 0.050 s. The mass of the paper is 0.003 kg. Show that the force of the punch on the paper is only 1.5 N.

50. Suzie Skydiver with her parachute has a mass of 50 kg.

(a) Before opening her chute, what force of air resistance will she encounter when she reaches terminal velocity?

(b) What force of air resistance will she encounter when she reaches a lower terminal velocity after the chute is open?

(c) Discuss why your answers are the same or different.

51. If you stand next to a wall on a frictionless skateboard and push the wall with a force of 40 N, how hard does the wall push on you? Show that if your mass is 80 kg, your acceleration is 0.5 m/s^2 away from the wall.

52. A force F acts in the forward direction on a cart of mass m . A friction force f opposes this motion.

(a) Use Newton's second law and show that the acceleration of the cart is $\frac{F-f}{m}$.

(b) Show that if the cart's mass is 4.0 kg, the applied force is 12.0 N, and the friction force is 6.0 N, the cart's acceleration is 1.5 m/s^2 .

53. A firefighter of mass 80 kg slides down a vertical pole with an acceleration of 4 m/s^2 . Show that the friction force that acts on the firefighter is 480 N.

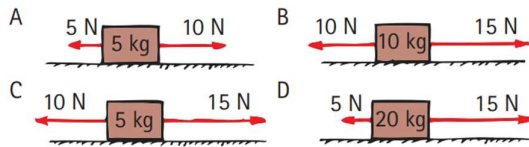
54. A rock band's tour bus, mass M , is accelerating away from a stop sign at rate a when a piece of heavy metal, mass $M/5$, falls onto the top of the bus and remains there.

(a) Show that the bus's acceleration is now $\frac{5}{6}a$.

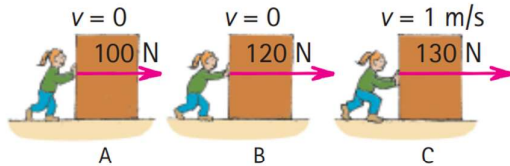
(b) If the initial acceleration of the bus is 1.2 m/s^2 , show that when the bus carries the heavy metal with it, the acceleration will be 1.0 m/s^2 .

THINK AND RANK (ANALYSIS)

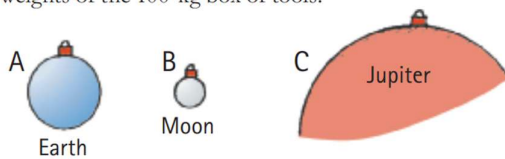
55. Boxes of various masses are on a friction-free level table.
 (a) Rank, from greatest to least, the net forces on the boxes.
 (b) Rank, from greatest to least, the accelerations of the boxes.



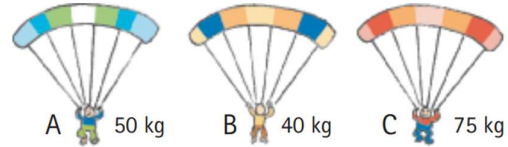
56. In cases A, B, and C, the crate is in equilibrium (no acceleration). Rank, from greatest to least, the amounts of friction between the crate and the floor in these three cases.



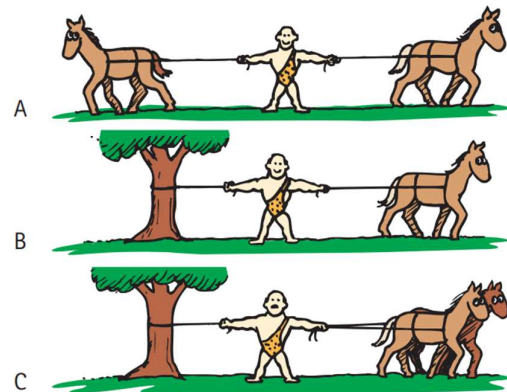
57. Consider a 100-kg box of tools in the locations A, B, and C. (a) Rank, from greatest to least, the masses of the 100-kg box of tools. (b) Rank, from greatest to least, the weights of the 100-kg box of tools.



58. Three parachutists, A, B, and C, have reached terminal velocity at the same altitude. (a) Rank their terminal velocities from fastest to slowest. (b) Rank the order of their reaching the ground from longest time to shortest time.



59. The strong man is pulled in the three situations shown. Rank, from least to greatest, the amount of tension in the rope in his right hand (the one attached to the tree in B and C).



Readiness Assurance Test (RAT)

Choose the BEST way to complete the statement.

1. If gravity between the Sun and Earth suddenly vanished, Earth would continue moving in
 - A. a curved path.
 - B. a straight-line path.
 - C. a path directed to Earth's surface.
 - D. an outward spiral path.
2. A ball rolls down a curved ramp as shown. As its speed increases, its rate of gaining speed
 - A. increases.
 - B. decreases.
 - C. remains unchanged.
 - D. none of these
3. A block of ice sliding without friction down an icy flat incline gains speed, while its acceleration
 - A. increases.
 - B. decreases.
 - C. remains unchanged.
 - D. is zero.
4. The reason why a 10-kg rock falls no faster than a 5-kg rock in free fall is that the
 - A. 10-kg rock has greater acceleration.
 - B. 5-kg rock has greater acceleration.
 - C. force of gravity is the same for both.
 - D. force/mass ratio is the same for both.
5. As mass is added to a cart pushed by a constant force, its acceleration
 - A. remains constant.
 - B. increases.
 - C. decreases.
 - D. quickly reaches zero.
6. The amount of air resistance that acts on a wingsuit flyer (and a flying squirrel) depends on the flyer's
 - A. area.
 - B. speed.
 - C. area and speed.
 - D. acceleration.
7. You drop a pillow off the edge of the administration building on your campus. While the pillow is falling, its speed
 - A. and acceleration both increase.
 - B. and acceleration both decrease.
 - C. increases and its acceleration decreases.
 - D. decreases and its acceleration increases.
8. Alex pulls on the end of a spring attached to a wall. The reaction to Alex's pull on the spring is
 - A. the wall pulling oppositely on the spring.
 - B. the spring pulling on Alex.
 - C. both the wall and the spring pulling on Alex.
 - D. none of these
9. The amount of force with which a boxer's punch lands depends mainly on the
 - A. physical condition of the boxer.
 - B. mass of what's being hit.
 - C. boxer's attitude.
 - D. none of these
10. The force that propels a rocket is provided by
 - A. gravity.
 - B. Newton's laws of motion.
 - C. its exhaust gases.
 - D. the atmosphere against which the rocket pushes

