PH 201 Homework Assignment Chapter on Forces – 45 Problems Total

1. An airplane has a mass of 3.1 x 10^4 kg and takes off under the influence of a constant net force of 3.7 x 10^4 N. What is the net force that acts on the plane's 78-kg pilot?

Solution for Problem 1

2. Two horizontal forces, $\overrightarrow{F_1}$ and $\overrightarrow{F_2}$, are acting on a box, but only $\overrightarrow{F_1}$ is shown in the drawing. $\overrightarrow{F_2}$ can point either to the right or to the left. The box moves only along the *x* axis. There is no friction between the box and the surface. Suppose that $\overrightarrow{F_1} = +9.0\ N$ and the mass of the box is 3.0 kg. Find the magnitude and direction of $\overrightarrow{F_2}$ when the acceleration of the box is **(a)** +5.0 m/s^2, **(b)** –5.0 m/s^2, and **(c)** 0 m/s^2.

Solution for Problem 2

3. In the amusement park ride known as Magic Mountain Superman, powerful magnets accelerate a car and its riders from rest to 45 m/s (about 100 mi/h) in a time of 7.0 s. The combined mass of the car and riders is 5.5 x 10^3 kg. Find the average net force exerted on the car and riders by the magnets.

Solution for Problem 3

4. Scientists are experimenting with a kind of gun that may eventually be used to fire payloads directly into orbit. In one test, this gun accelerates a 5.0-kg projectile from rest to a speed of 4.0 x 10^3 m/s. The net force accelerating the projectile is 4.9 x 10^5 N. How much time is required for the projectile to come up to speed?

Solution for Problem 4

5. A 1580-kg car is traveling with a speed of 15.0 m/s. What is the magnitude of the horizontal net force that is required to bring the car to a halt in a distance of 50.0 m?

Solution for Problem 5

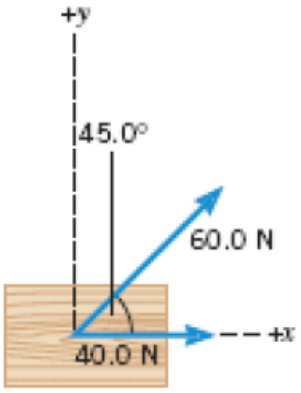
6. The space probe *Deep Space 1* was launched on October 24, 1998. Its mass was 474 kg. The goal of the mission was to test a new kind of engine called an ion propulsion drive. This engine generated only a weak thrust, but it could do so over long periods of time with the consumption of only small amounts of fuel. The mission was spectacularly successful. At a thrust of 56 mN how many days were required for the probe to attain a velocity of 805 m/s (1800 mi/h), assuming that the probe started from rest and that the mass remained nearly constant?

Solution for Problem 6

7. An electron is a subatomic particle (m = 9.11 x 10^{-31} kg) that is subject to electric forces. An electron moving in the +x direction accelerates from an initial velocity of +5.40 x 10^5 m/s to a final velocity of +2.10 x 10^6 m/s while traveling a distance of 0.038 m. The electron's acceleration is due to two electric forces parallel to the x axis: $\overrightarrow{F_1} = +7.50 \times 10^{-17} N$ and $\overrightarrow{F_2}$, which points in the -x direction. Find the magnitudes of **(a)** the net force acting on the electron and **(b)** the electric force $\overrightarrow{F_2}$.

Solution for Problem 7

8. Only two forces act on an object (mass = 3.00 kg), as in the drawing. Find the magnitude and direction (relative to the x axis) of the acceleration of the object.



Solution for Problem 8

9. A rocket of mass 4.50 x 10^5 kg is in flight. Its thrust is directed at an angle of 55.0° above the horizontal and has a magnitude of 7.50 x 10^6 N. Find the magnitude and direction of the rocket's acceleration. Give the direction as an angle above the horizontal.

Solution for Problem 9

10. When a parachute opens, the air exerts a large drag force on it. This upward force is initially greater than the weight of the sky diver and, thus, slows him down. Suppose the weight of the sky diver is 915 N and the drag force has a magnitude of 1027 N. The mass of the sky diver is 93.4 kg. What are the magnitude and direction of his acceleration?

Solution for Problem 10

11. Two skaters, a man and a woman, are standing on ice. Neglect any friction between the skate blades and the ice. The mass of the man is 82 kg, and the mass of the woman is 48 kg. The woman pushes on the man with a force of 45 N due east. Determine the acceleration (magnitude and direction) of **(a)** the man and **(b)** the woman.

Solution for Problem 11

12. At a time when mining asteroids has become feasible, astronauts have connected a line between their 3500-kg space tug and a 6200-kg asteroid. Using their tug's engine, they pull on the asteroid with a force of 490 N. Initially the tug and the asteroid are at rest, 450 m apart. How much time does it take for the tug and the asteroid to meet?

Solution for Problem 12

13. A 325-kg boat is sailing 15.0° north of east at a speed of 2.00 m/s. Thirty seconds later, it is sailing 35.0° north of east at a speed of 4.00 m/s. During this time, three forces act on the boat: a 31.0-N force directed 15.0° north of east (due to an auxiliary engine), a 23.0-N force directed 15.0° south of west (resistance due to the water), and $\overrightarrow{F_W}$ (due to the wind). Find the magnitude and direction of the force $\overrightarrow{F_W}$. Express the direction as an angle with respect to due east.

Solution for Problem 13

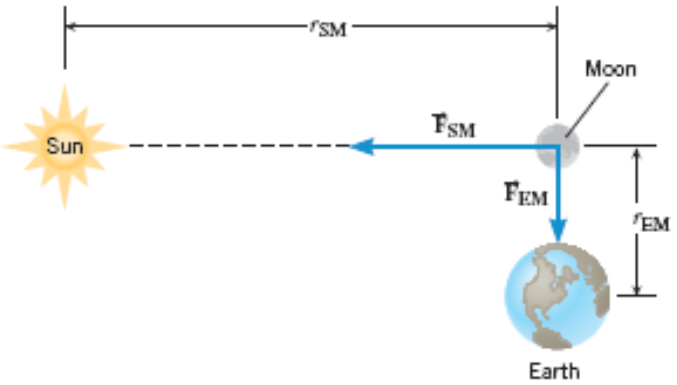
14. Mars has a mass of 6.46×10^{23} kg and a radius of 3.39×10^{6} m. **(a)** What is the acceleration due to gravity on Mars? **(b)** How much would a 65-kg person weigh on this planet?

Solution for Problem 14

15. Synchronous communications satellites are placed in a circular orbit that is 3.59×10^{7} m above the surface of the earth. What is the magnitude of the acceleration due to gravity at this distance?

Solution for Problem 15

16. The drawing (not to scale) shows one alignment of the sun, earth, and moon. The gravitational force $\overrightarrow{F_{SM}}$ that the sun exerts on the moon is perpendicular to the force $\overrightarrow{F_{EM}}$ that the earth exerts on the moon. The masses are: mass of sun = 1.99 x 10^{30} kg, mass of earth = 5.98 x 10^{24} kg, mass of moon = 7.35 x 10^{22} kg. The distances shown in the drawing are r_{SM} = 1.50 x 10^{11} m and r_{EM} = 3.85 x 10^{8} m. Determine the magnitude of the net gravitational force on the moon.



Solution for Problem 16

17. A spacecraft is on a journey to the moon. At what point, as measured from the center of the earth, does the gravitational force exerted on the spacecraft by the earth balance that exerted by the moon? This point lies on a line between the centers of the earth and the moon. The distance between the earth and the moon is 3.85 x 10^{8} m, and the mass of the earth is 81.4 times as great as that of the moon.

Solution for Problem 17

18. A neutron star has a mass of 2.0 x 10^{30} kg (about the mass of our sun) and a radius of 5.0 x 10^{3} m (about the height of a good-sized mountain). Suppose an object falls from rest near the surface of such a star. How fast would this object be moving after it had fallen a distance of 0.010 m? (Assume that the gravitational force is constant over the distance of the fall and that the star is not rotating.)

Solution for Problem 18

19. The sun is more massive than the moon, but the sun is farther from the earth. Which one exerts a greater gravitational force on a person standing on the earth? Give your answer by determining the ratio F_{sun}/F_{moon} of the magnitudes of the gravitational forces. Use the data on the inside of the front cover.

Solution for Problem 19

20. A 35-kg crate rests on a horizontal floor, and a 65-kg person is standing on the crate. Determine the magnitude of the normal force that **(a)** the floor exerts on the crate and **(b)** the crate exerts on the person.

Solution for Problem 20

21. A rocket blasts off from rest and attains a speed of 45 m/s in 15 s. An astronaut has a mass of 57 kg. What is the astronaut's apparent weight during takeoff?

Solution for Problem 21

22. A woman stands on a scale in a moving elevator. Her mass is 60.0 kg, and the combined mass of the elevator and scale is an additional 815 kg. Starting from rest, the elevator accelerates upward. During the acceleration, the hoisting cable applies a force of 9410 N. What does the scale read during the acceleration?

Solution for Problem 22

23. A Mercedes-Benz 300SL (m = 1700 kg) is parked on a road that rises 15° above the horizontal. What are the magnitudes of **(a)** the normal force and **(b)** the static frictional force that the ground exerts on the tires?

Solution for Problem 23

24. A person pushes on a 57-kg refrigerator with a horizontal force of -267 N; the minus sign indicates that the force points in the $-x$ direction. The coefficient of static friction is 0.65. **(a)** If the refrigerator does not move, what are the magnitude and direction of the static frictional force that the floor exerts on the refrigerator? **(b)** What is the magnitude of the largest pushing force that can be applied to the refrigerator before it just begins to move?

Solution for Problem 24

25. A 6.00-kg box is sliding across the horizontal floor of an elevator. The coefficient of kinetic friction between the box and the floor is 0.360. Determine the kinetic frictional force that acts on the box when the elevator is **(a)** stationary, **(b)** accelerating upward with an acceleration whose magnitude is 1.20 m/s^2, and **(c)** accelerating downward with an acceleration whose magnitude is 1.20 m/s^2.

Solution for Problem 25

26. An 81-kg baseball player slides into second base. The coefficient of kinetic friction between the player and the ground is 0.49. **(a)** What is the magnitude of the frictional force? **(b)** If the player comes to rest after 1.6 s, what was his initial velocity?

Solution for Problem 26

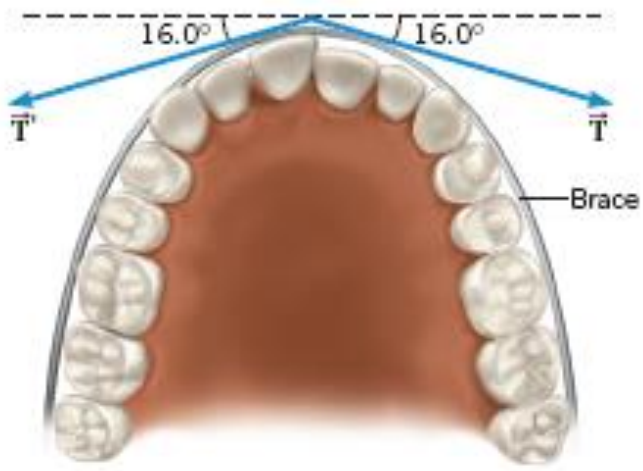
27. Air rushing over the wings of high-performance race cars generates unwanted horizontal air resistance but also causes a vertical *downforce,* which helps the cars hug the track more securely. The coefficient of static friction between the track and the tires of a 690-kg race car is 0.87. What is the magnitude of the maximum acceleration at which the car can speed up without its tires slipping when a 4060-N downforce and an 1190-N horizontal-air-resistance force act on it?

Solution for Problem 27

28. Three forces act on a moving object. One force has a magnitude of 80.0 N and is directed due north. Another has a magnitude of 60.0 N and is directed due west. What must be the magnitude and direction of the third force, such that the object continues to move with a constant velocity?

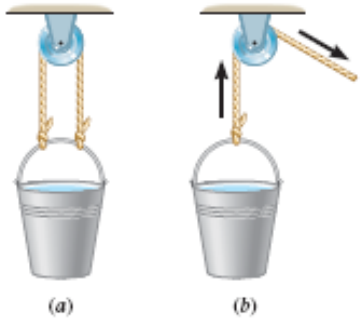
Solution for Problem 28

29. The drawing shows a wire tooth brace used by orthodontists. The topmost tooth is protruding slightly, and the tension in the wire exerts two forces $\vec{T}$ and $\vec{T'}$ on this tooth in order to bring it back into alignment. If the forces have the same magnitude of 21.0 N, what is the magnitude of the net force exerted on the tooth by these forces?



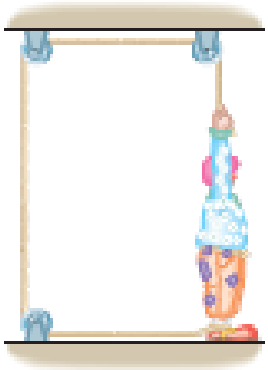
Solution for Problem 29

30. Part *a* of the drawing shows a bucket of water suspended from the pulley of a well; the tension in the rope is 92.0 N. Part *b* shows the same bucket of water being pulled up from the well at a constant velocity. What is the tension in the rope in part *b*?



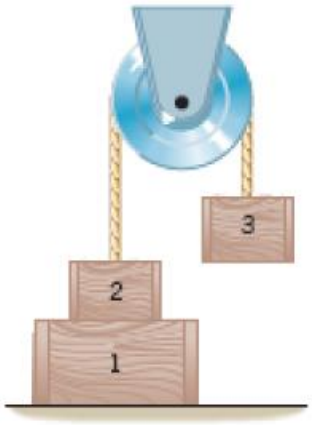
Solution for Problem 30

31. The drawing shows a circus clown who weighs 890 N. The coefficient of static friction between the clown's feet and the ground is 0.53. He pulls vertically downward on a rope that passes around three pulleys and is tied around his feet. What is the minimum pulling force that the clown must exert to yank his feet out from under himself?



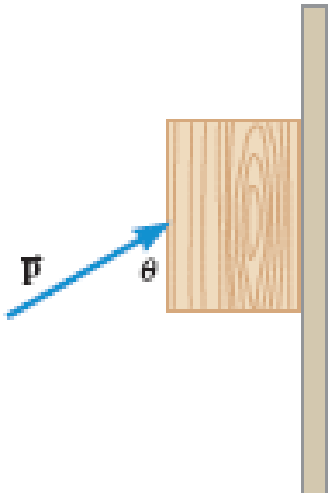
Solution for Problem 31

32. The drawing shows box 1 resting on a table, with box 2 resting on top of box 1. A massless rope passes over a massless, frictionless pulley. One end of the rope is connected to box 2, and the other end is connected to box 3. The weights of the three boxes are $W_1 = 55$ N, $W_2 = 35$ N, and $W_3 = 28$ N. Determine the magnitude of the normal force that the table exerts on box 1.



Solution for Problem 32

33. A block is pressed against a vertical wall by a force $\vec{P}$, as the drawing shows. This force can either push the block upward at a constant velocity or allow it to slide downward at a constant velocity. The magnitude of the force is different in the two cases, while the directional angle θ is the same. Kinetic friction exists between the block and the wall, and the coefficient of kinetic friction is 0.250. The weight of the block is 39.0 N, and the directional angle for the force $\vec{P}$ is $\theta = 30.0°$. Determine the magnitude of $\vec{P}$ when the block slides **(a)** up the wall and **(b)** down the wall.



Solution for Problem 33

34. The person in the drawing is standing on crutches. Assume that the force exerted on each crutch by the ground is directed along the crutch, as the force vectors in the drawing indicate. If the coefficient of static friction between a crutch and the ground is 0.90, determine the largest angle θ^{MAX} that the crutch can have just before it begins to slip on the floor.

Solution for Problem 34

35. A bicyclist is coasting straight down a hill at a constant speed. The combined mass of the rider and bicycle is 80.0 kg, and the hill is inclined at 15.0° with respect to the horizontal. Air resistance opposes the motion of the cyclist. Later, the bicyclist climbs the same hill at the same constant speed. How much force (directed parallel to the hill) must be applied to the bicycle in order for the bicyclist to climb the hill?

Solution for Problem 35

36. A fisherman is fishing from a bridge and is using a "45-N test line." In other words, the line will sustain a maximum force of 45 N without breaking. What is the weight of the heaviest fish that can be pulled up vertically when the line is reeled in **(a)** at a constant speed and **(b)** with an acceleration whose magnitude is 2.0 m/s^2?

Solution for Problem 36

37. A rescue helicopter is lifting a man (weight = 822 N) from a capsized boat by means of a cable and harness. **(a)** What is the tension in the cable when the man is given an initial upward acceleration of 1.10 m/s^2? **(b)** What is the tension during the remainder of the rescue when he is pulled upward at a constant velocity?

Solution for Problem 37

38. A man seeking to set a world record wants to tow a 109 000-kg airplane along a runway by pulling horizontally on a cable attached to the airplane. The mass of the man is 85 kg, and the coefficient of static friction between his shoes and the runway is 0.77. What is the greatest acceleration the man can give the airplane? Assume that the airplane is on wheels that turn without any frictional resistance.

Solution for Problem 38

39. A train consists of 50 cars, each of which has a mass of 6.8×10^3 kg. The train has an acceleration of $+8.0 \times 10^{-2}$ m/s^2. Ignore friction and determine the tension in the coupling **(a)** between the 30th and 31st cars and **(b)** between the 49th and 50th cars.

Solution for Problem 39

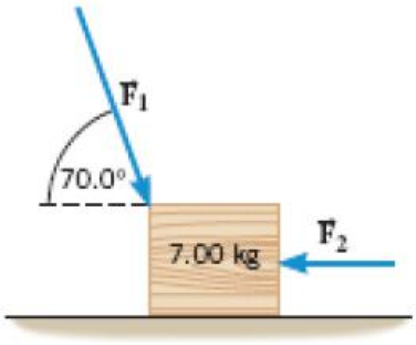
40. A penguin slides at a constant velocity of 1.4 m/s down an icy incline. The incline slopes above the horizontal at an angle of 6.9°. At the bottom of the incline, the penguin slides onto a horizontal patch of ice. The coefficient of kinetic friction between the penguin and the ice is the same for the incline as for the horizontal patch. How much time is required for the penguin to slide to a halt after entering the horizontal patch of ice?

Solution for Problem 40

41. A 5.00-kg block is placed on top of a 12.0-kg block that rests on a frictionless table. The coefficient of static friction between the two blocks is 0.600. What is the maximum horizontal force that can be applied before the 5.00-kg block begins to slip relative to the 12.0-kg block, if the force is applied to **(a)** the more massive block and **(b)** the less massive block?

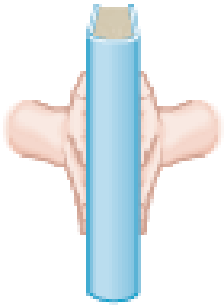
Solution for Problem 41

42. Two forces, $\overrightarrow{F_1}$ and , $\overrightarrow{F_2}$ **,** act on the 7.00-kg block shown in the drawing. The magnitudes of the forces are $F_1 = 59.0$ N and $F_2 = 33.0$ N. What is the horizontal acceleration (magnitude and direction) of the block?



Solution for Problem 42

43. A student presses a book between his hands, as the drawing indicates. The forces that he exerts on the front and back covers of the book are perpendicular to the book and are horizontal. The book weighs 31 N. The coefficient of static friction between his hands and the book is 0.40. To keep the book from falling, what is the magnitude of the minimum pressing force that each hand must exert?

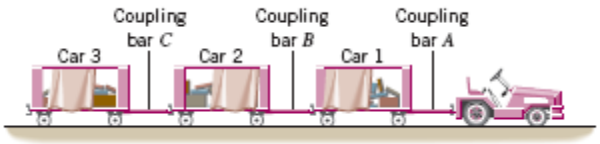


Solution for Problem 43

44. A mountain climber, in the process of crossing between two cliffs by a rope, pauses to rest. She weighs 535 N. As the drawing shows, she is closer to the left cliff than to the right cliff, with the result that the tensions in the left and right sides of the rope are not the same. Find the tensions in the rope to the left and to the right of the mountain climber.

Solution for Problem 44

45. At an airport, luggage is unloaded from a plane into the three cars of a luggage carrier, as the drawing shows. The acceleration of the carrier is 0.12 m/s^2, and friction is negligible. The coupling bars have negligible mass. By how much would the tension in *each* of the coupling bars *A*, *B*, and *C* change if 39 kg of luggage were removed from car 2 and placed in **(a)** car 1 and **(b)** car 3? If the tension changes, specify whether it increases or decreases.



Solution for Problem 45

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