Forces.

1. Sussex County, Delaware, is home to the annual post-Halloween *Pumpkin Chunkin'* shoot-off, where contestants construct cannons to launch pumpkins and compete for the greatest distance. The world record pumpkin chunkin' using an air cannon is 5545 ft (just over one mile). Assuming an initial firing angle of 45º, what is the initial speed needed for such a shot?

2. Suppose a rocket is launched from Cape Canaveral with an acceleration of +32 m/s^2. What is the apparent weight of a 95-kg astronaut?

3. A catcher stops a 92 mi/h fastball in his glove, bringing it to rest in $\frac{1}{2}$ ft. If the force exerted by the catcher on the ball is 190 lb, what is the mass of the ball?

4. A sledge (including load) weighs 750 N. It is pulled across level snow – which, for this problem, can be seen as being frictionless – by a team of Alaskan malamutes and Siberian huskies, exerting a horizontal force on it. How much force is applied by the dog team pulling the sledge 1200 m if the sledge accelerates at 1.8 m/s^2?

5. As part of a take-home physics experiment, you stand on a bathroom scale in a high-speed express elevator. Though your normal weight is 135 lb, the scale at the moment reads 150 lb. What is the magnitude and direction of the elevator's acceleration?

6. Galileo Galilei once wrote "Nature is relentless and unchangeable, and it is indifferent as to whether its hidden reasons and actions are understandable to man or not." What does that mean?

7. For the past ten days, you have been held without bond in a cell on the second story of the Ouagadougou City Jail in Burkina Faso. You manage to loosen a bar in the window and squeeze through. In your escape attempt, you have to leap into the open bed of a garbage truck parked below. If the side of the truck is 7.5 m from the building, and you are 12 m above the bed of the truck, what must your minimum horizontal velocity have to be in order to safely land in the garbage scow below?

8. In a rainstorm, the vertical velocity of a raindrop typically reaches a maximum of –190 km/h. If a 0.5-mg raindrop strikes you on the head and comes to a complete stop in a distance of 2.5 mm, what force did you feel from a single raindrop? Assume the raindrops are falling vertically.

9. Wile E. Coyote has decided to employ an Acme™ Ultra-portable Snowmaking Machine to create a near-frictionless surface on the side of a mountain. If he starts at rest down the 475 m-long slope at an angle of 22º above the horizontal, how fast will Wile E. Coyote be traveling when he reaches the edge of the road where the Roadrunner waits below?

10. On the aircraft carrier, USS *John C. Stennis*, a Navy F-14 jet can be catapulted from zero to 240 km/h in exactly 2 s. If the average force exerted by the catapult is 5.1×10^6 N, what is the mass of the jet?

11. A 250-gr (16.2 g) bullet fired from a rifle at an initial speed of 465 m/s into a fencepost comes to a complete stop in 0.15 m. (a) What is the deceleration of the bullet? (b) How much force did the post apply to the bullet?

12. A Ferrari 575 *Maranello* F1 (which is generally considered a pretty "hot" car) is racing along a straight, horizontal highway at a speed of 63 m/s when a monkey jumps out of a tree and lands 135 m in front of the oncoming car. The driver slams on the brakes and stops in exactly 4.5 s. (a) What is the mass of the car if the brakes apply a force of 7490 N? (b) How far will the Ferrari 575 *Maranello* F1 travel before stopping? (c) Will the Ferrrari 575 hit the monkey? Personally, I'm thinking that the monkey is seriously dead meat*!* ☠

13. Johannes Kepler originally believed that the spacing of planetary orbits was due to the ratio of the five Platonic solids with respect to the radii of revolution. (a) Identify the five Platonic solids. (b) Although it was certainly incorrect, why was it considered a reasonable approach to solving planetary motion

14. On October 9, 1992, a 27-lb meteorite struck a car in Peekskill, NY, leaving a dent 22 cm deep in the trunk. (a) If the meteorite struck the car with a speed of 535 m/s, what was the magnitude of its deceleration, assuming it to be constant? (b) What was the force applied by the meteorite to the car?

15. In order to obtain enough money to escape from Burkina Faso and make your way back to Michigan, you decide to rob a bank. The teller at the central Ouagadougou branch of the Caisse Nationale d'Epargne – who thinks you have a gun hidden in your tidy whities – hands over 390,000 *Communaute Financiere Africaine* francs (which you discover later is worth about $750). She loads it into a paper grocery bag, whose handles will tear off if a force greater than 115 lb is applied to them. If a single *CFA* franc weighs $\frac{1}{32}^{\text{nd}}$ of an ounce, can you safely make off with the loot?

16. If the velocity of an object is nonzero, can its acceleration be zero?

17. On August 25, 1894, Chicago Cubs catcher William Schriver caught a baseball thrown from the top of the 555-ft tall Washington Monument. (a) If the ball was thrown horizontally with an initial speed of 25 ft/s, how far out from the Monument did it land? (b) What was the ball's final velocity when caught? (c) If Schriver's catcher's mitt was pushed downward a displacement of exactly 4 ft before stopping, what was the force of the baseball on the glove?

18. In Isaac Newton's *Principia*, he writes "Nature does nothing . . . in vain, and more is in vain when less will serve." What does this mean?

19. A sledge (including load) weighs 750 N. It is pulled across level snow by a team of Alaskan malamutes and Siberian huskies. The coefficient of kinetic friction between the snow and the sled runners is 0.075. (a) How much force is applied by the dog team pulling the sledge 1200 m if the sledge travels at a constant velocity? (b) How much force is applied by the dog team pulling the sledge 1200 m if the sledge *accelerates* at 1.8 m/s^2?

20. A hot air balloon rises from the ground at a rate of $2\frac{1}{2}$ m/s. A champagne bottle is opened to celebrate the takeoff, expelling the cork with a speed of 5.0 m/s. When opened, the bottle is pointed horizontally and is 6.75 m above the ground. (a) What is the initial speed of the cork, as seen by an observer on the ground? (b) What is the maximum height of the cork above the ground? (c) How far out, relative to its original position, did the cork land? (d) What was the velocity of the cork upon impact with the ground?

21. Approximately how many M&Ms can fit in a Volkswagen Beetle?

22. If the acceleration of an object is nonzero, can its velocity be zero?

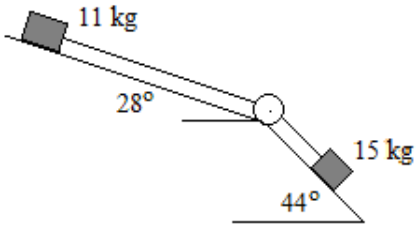
23. A high-velocity Acme™ jet-powered sled weighs 175 lb when carrying Wile E. Coyote (who has a mass of $1\frac{1}{4}$ sl). According to the owner's manual, the sled can reach a speed of 475 mi/h in a distance 210 ft on a perfectly frictionless horizontal surface. (a) How much force can be applied by jet engine on the sled? (b) If the coefficient of friction between the bottom of the sled and the desert floor is 0.64, how much force does Wile E. Coyote experience when he fires off the engine? (c) What is his acceleration? (d) How far does he travel in 60 s?

24. What exactly *is* a force? How can you define it without using Newton's 2nd law of motion?

25. While attempting to thwart Murdoch's latest attack, MacGyver's boss Pete Thornton is locked in his apartment slowly dying of carbon monoxide poisoning. In order to save him, MacGyver tries to break through the 150-N apartment door by tying a fire hose to the door handle and an elevator handrail, then sending the 245-kg elevator *down*. He cuts the fire hose with his Swiss army knife, ties the nozzle end to the door, the other end to the hand rail, and lays the hose flat against the ground so the elevator's doors won't close on it. When the elevator goes down, it accelerates from rest to 1.3 m/s in a distance of 2.1 m. (a) What is the acceleration of the elevator? (b) How much force does the elevator apply to the door? (c) Is it enough to pull open the door so that MacGyver can reach in and unlock the deadbolt and chain door lock? Assume the deadbolt and chain lock apply a frictional force of 110 N. (d) Why didn't MacGyver save Pete Thornton by duct taping the fire hose to a paper clip, connecting the entire mess to the nearest substation located just outside the apartment complex, discharging the neighborhood power relays, and blowing the door off its hinges? (e) Or simply kicking the door in?

26. In 1676, Robert Hooke stated that "the power of any springy body is in the same proportion with the extension." What did he mean by this?

27. Two masses, one 11 kg and the other 15 kg, are placed on a set of surfaces with a coefficient of friction of 0.26 as shown below. (a) Draw a large, correctly-labeled free-body diagram. (b) What is the acceleration of the two blocks? (c) If the two masses start at rest, in what direction and how fast will the masses be moving after $1\frac{3}{4}$ s? Assume the string is massless and the pulley is frictionless as well.



28. A physics textbook is placed on a smooth wooden plank. When the plank is tilted 35° above the horizontal, the book slides downslope with an acceleration of 1.44 m/s^2. What is the coefficient of kinetic friction?

29. Ospreys – a small, eagle-like bird – tuck their wings and free fall straight down when diving for fish. Suppose an osprey starts its dive from a height of 35 m and cannot change its path once committed. If it takes a fish 0.15 s to perform evasive action, at what *minimum* height above the water must it spot the osprey in order to escape? Assume the fish is at the surface of the water.

30. Hooke's law states that the restoring force $\boldsymbol{F} = -k\boldsymbol{x}$, where k is the spring constant. Do all springs obey this law?

31. A sled weighing 28 lb is pulled horizontally across a snowfield in which the coefficient of kinetic friction is equal to 0.071. A penguin weighing 63 lb jumps on the sled and goes for a ride as it passes. If the coefficient of static friction between the penguin's butt and the sled is 0.71, what is the maximum horizontal force that can be applied to the sled before the penguin begins to slide off?

32. (a) Why do we not take into account the surface area when dealing with friction? (b) How would the effects of surface area change the behavior of friction?

33. A 35-kg girl and a $7\frac{1}{2}$-kg sled are on the surface of a frozen lake separated by a distance of 22 m. Using an attached rope, the girl exerts a 5.2-N force on the sled, pulling it toward her. (a) What is the acceleration of the sled? (b) What is the acceleration of the girl? (c) How far from the girl's initial position do they meet? (d) How fast is the sled moving when it meets the girl? (e) How fast is the girl moving? Assume that no frictional forces act on either body.

34. After a series of adventures (not unlike that of the greatest television character of all time: *MacGyver*), you manage to smuggle yourself out of Burkina Faso onto an outbound cargo plane headed for Nigeria. In order to avoid being discovered, you slide a large box of what appears to be agricultural products around the storage container in which you are concealed, creating a small yet comfortable hiding space. (a) How much force must you apply to move the box if the coefficient of friction between the bottom of the box and the floor of the airplane is 0.42 and the box weighs 210 N? (b) How fast will the box be moving after $\frac{1}{10}$ s? (c) How far will have moved?

35. An astronaut on Earth places a bowling ball with a mass of 7.6 kg on a scale. (a) What is the reading on the scale? (b) If the scale compresses 2.4 cm, what is the spring constant?

36. An astronaut on a strange planet places a bowling ball with a mass of 7.6 kg on a scale. If the bowling ball compresses the scale on Earth by 2.4 cm, what is the gravitational acceleration on the planet if the scale is only compressed 1.8 cm?

37. 

After his unsuccessful attempt at running down the Roadrunner in his high-velocity Acme™ jet-powered sled, Wile E. Coyote decides to rocket himself off a $2\frac{1}{2}$-m long ramp angled 35º above the desert floor in another misguided try at catching dinner. He constructs an Acme™ Firecracker Rocket, which weighs 210 N when carrying Wile E. Coyote (who has a mass of $12\frac{1}{6}$ kg). The rocket is calculated to be able to reach a speed of 620 km/h in 4.6 s on a perfectly frictionless surface. (a) How much force can the rocket apply? (b) If the coefficient of friction between the bottom of the rocket and the ramp is 0.21, how much force does Wile E. Coyote experience when he fires off the engine? (c) What is his acceleration? (d) How fast is he traveling when he leaves the end of the ramp? (e) How far will he travel before hitting the desert floor? (f) How long was he in the air before impact? (g) If, when Wile E. Coyote hits the ground, he comes to a complete stop in $\frac{1}{200}$ s, what deceleration does he undergo? (h) What is the force he experiences upon impact? (i) Does he survive?

38. Suppose that while working out in space, an astronaut accidentally hits her thumb with a "weightless" hammer. Will it hurt? Why or why not?