1. A satellite of mass 50.0 kg is pulled by 45$\underline{0}$ N of gravity. Small thrusters are used to maneuver the satellite in its orbit. (a) What thrust would cause the satellite to move with a constant velocity? Find the acceleration of the satellite in response to the following thrusts: (b) 205 N up, (c) 205 N down, and (d) 205 N right.

2. A rocket equivalent to the Saturn V with thrust 34 MN firing for 120 s would cause what amount of change in velocity of Apophis, mass 6.1×10^{10} kg? Given the relative velocity of approach is 5780 m/s, would this be enough to avert disaster?

3. Impact of Apophis, $m = 6.1 \times 10^{10}$ kg, can be modeled empirically by: $v = 5773 - 4481000/(t - 65\underline{0}000)$ (in meters and seconds). Ignore air resistance.
(a) Find values of t, v, and F at impact.
(b) At what point would a thrust of 34 MN be enough to prevent acceleration?

4. An elevator car of mass 1570 kg is raised and lowered by a cable. Determine the force that the cable exerts on the car under the following circumstances: (a) car accelerates upward at 2.00 m/s^2 from rest, (b) car rises at a constant 3.00 m/s, (c) car decelerates 1.50 m/s^2 while rising, and (d) car lowers at a constant 3.00 m/s.

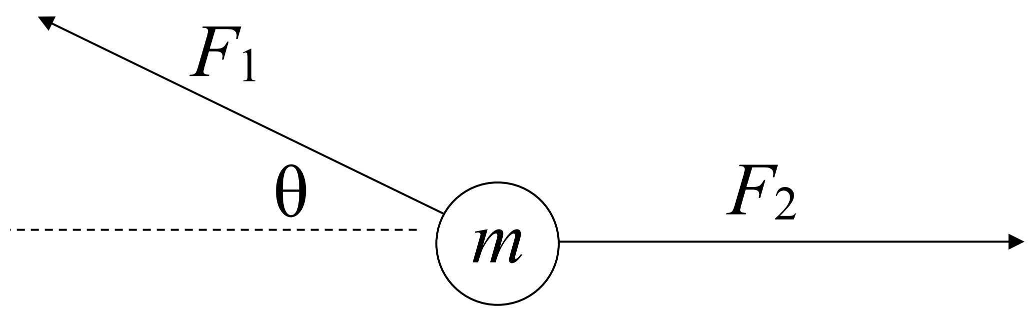
5. A balloon of a known mass or weight is dropped from a known height and timed. Determine the average amount of air resistance that acts on it.

6. An object that weighs 20.0 N is thrown by a person. Determine the resulting acceleration if the force exerted by the person is: (a) 30.0 N downward, and (b) 30.0 N rightward. (c) What force would the person have to exert in order that the object accelerate 4.00 m/s^2 directly to the left?

7. A certain rope has a tensile strength of 5.0 kN – this is the greatest force it can exert without breaking. Suppose this rope is used for rappelling. What is the maximum deceleration of a 50.0 kg rappeller that the rope can withstand? Repeat for a 100.0 kg person.

8. An object of mass 5.0 kg is subjected to a force in newtons of $\vec{F} = (3t^2 - 4t)\hat{\imath}$, where t is measured in seconds. The object has velocity $\vec{v} = -7\,\frac{\text{m}}{\text{s}}\,\hat{\imath}$ at $t = 0$. Determine the acceleration and velocity of the object at $t = 9.0$ s.

9. As shown in the diagram below a mass *m* is pulled by two forces (and gravity). (a) Determine the value of each force in terms of relevant variables and constants. (b) If force F_2 suddenly ceases to exist what will be the instantaneous acceleration of the mass?



10. Two astronauts aboard the space station bump into one another. Astronaut Jones, mass 90.0 kg is floating to the right and collides with Astronaut Smith, mass 80.0 kg initially at rest. If Smith is accelerated 2.00 m/s^2, right find: (a) The resulting acceleration of Jones, (b) the force that Jones exerts on Smith, and (c) the force that Smith exerts on Jones.

11. A doomed skydiver of mass 85.0 kg whose chute failed to open tries to slow himself by removing his 10.0 kg pack and throwing it downward. He exerts a downward force of 50.0 N on the pack. (a) Ignoring air resistance, determine the resulting accelerations of the skydiver and the pack. (b) What if air resistance is not ignored and the skydiver is at terminal velocity?

12. Use a CBR to measure a book of known weight that falls and is caught by a student. Use the velocity vs. time graph and your knowledge of physics to find the force that the falling book exerts on the student's hands.

13. A student of mass 75.0 kg stands at rest on the floor. (a) Find the normal force the floor exerts on his feet. (b) Find the normal force of his feet on the floor if he jumps upward with acceleration 2.50 m/s^2. (c) Find the normal force if he pushes downward on a nearby table with a force of 50.0 N.

14. A bowling ball is prevented from rolling down an incline of 30.0° by a student pulling parallel to the incline. Based on the known weight of the ball determine the normal force that acts upon it and the amount of force that the student has to exert.

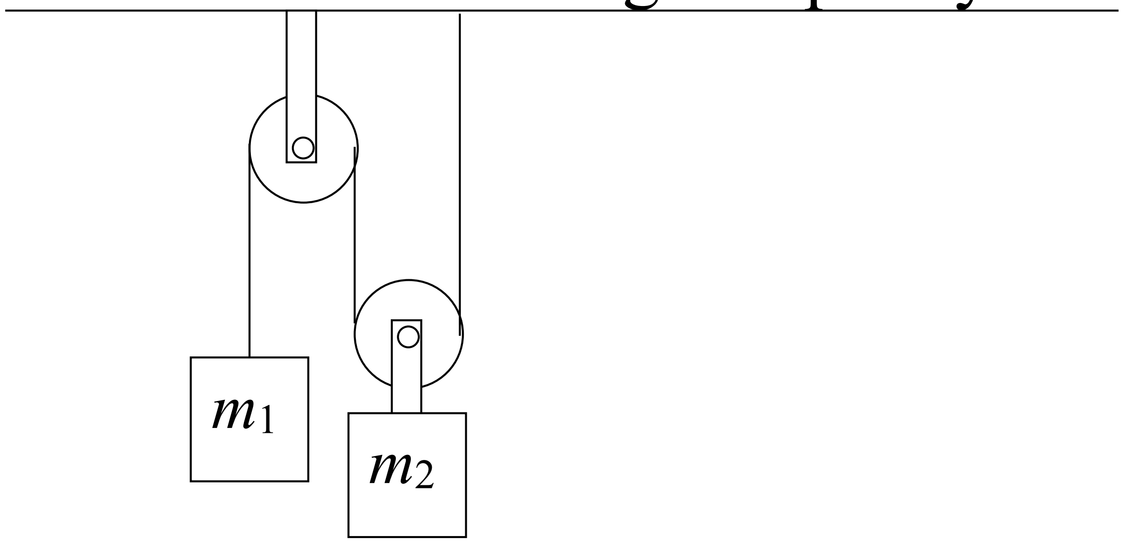
15. A 500.0 gram mass sits atop a 1.40 kg book. A force of 30.0 N upward is applied to the bottom of the book. (a) Analyze as one object to determine the acceleration. (b) Analyze the forces on the mass to solve for the force that the book exerts on it. (c) Analyze the forces on the book to solve for the force that the mass exerts on it.

16. A man of mass 100.0 kg climbs a rope of mass 2.00 kg that hangs from the ceiling of a gym. Every time the man lifts himself a bit higher he accelerates upward 0.50 m/s^2. Determine the maximum tension in the rope that occurs during his climb to the top. At what part of the rope does this occur? Where is the man when it occurs?

17. Determine expressions for the acceleration and tension for Atwood's machine, assuming a massless, frictionless pulley and massless string.

18. An object of mass M is pulled across a level surface without friction by a string that passes over a pulley. At the end of the string is an object with mass m. Determine the acceleration and the tension in the string, assuming massless string and a massless, frictionless pulley.

19. Examine the diagram below. Solve for the acceleration of each mass. Ignore friction and mass of the string and pulleys.



20. The coefficients of friction for an old physics book upon a shelf are: $\mu_s = 0.50$ and $\mu_k = 0.40$. Suppose the book has weight 14.5 N and a horizontal force is applied to it. (a) Determine the maximum force that can be applied without moving the book. (b) Determine the force required to keep the book moving at a constant speed across the shelf. (c) If the magnitude of the applied force is increased gradually, find the initial acceleration of the book just as it starts to move.

21. A car with speed v_o applies the brakes and slows to a stop. Derive and simplify an equation for the stopping distance d in terms of v_o and μ.

22. Measure the mass and sliding deceleration of a block across a level surface. Then add 500.0 g to the block and accelerate it with 400.0 g in a modified Atwood's machine. (a) Determine the coefficient of sliding friction. (b) Find the acceleration when pulled by the 400.0 g mass. (c) Find the tension in the string as it is pulled.

23. Observe a fan cart reversing direction and determine its acceleration before and after. (a) Determine μ. (b) Determine the thrust of the fan. (c) Determine the amount of mass that when added to the cart will prevent it from accelerating in a forward direction (will cause it to stop instead of reverse direction).

24. A traveler pulls a suitcase of mass 8.00 kg across a level surface by pulling on the handle 20.0 N at an angle of 50.0° relative to horizontal. Friction against the suitcase can be modeled by $\mu_k = 0.100$. (a) Determine the acceleration of the suitcase. (b) What amount of force applied at the same angle would be needed to keep the suitcase moving at constant velocity?

25. A block of mass 2.0 kg rests on a level surface where $\mu_k = 0.30$ and $\mu_s = 0.40$. If the block experiences an applied force of 10.0 N directed 30.0° downward relative to horizontal, determine the resulting acceleration. At what angle would no amount of applied force cause the block to move?

26. A horse of mass 509 kg pulls a sleigh of mass 255 kg and both horse and sleigh accelerate 0.500 m/s^2. The coefficient of friction for the sleigh is 0.15 as it moves over the snow. (a) Find the force that the horse must exert on the sleigh. (b) Determine the amount of horizontal force that the horse's feet must exert.

27. Consider the previous problem generically. An animal or vehicle of mass M pulls an object of mass m across a level surface. Derive an expression for the largest value of m in terms of μ_s for the animal/vehicle, μ_k for the pulled object, and the acceleration a of both.

28. A baseball has mass 0.145 kg and has a terminal velocity of 45 m/s. Suppose that air resistance against the ball is modeled with the formula $\mathbf{F}_{drag} = -k\mathbf{v}$. (a) Determine the value of k. Supposing the ball is moving under the influence of drag and gravity determine its acceleration in the following cases: (b) moving upward at 20.0 m/s, (c) moving downward at 30.0 m/s. (d) moving horizontally at 40.0 m/s.

29. Repeat the above problem using the model $F_{drag} = kv^2$.

30. Another baseball is prepared that has the same diameter and the same external surface as the first, but its mass is 1.45 kg (it is more dense and has more mass inside). What is the terminal speed of this more massive ball using the model $F_{drag} = kv^2$?

31. In 2013 Zack Hample caught a baseball dropped from a helicopter supposedly at a height 320 m. Video appears to show the ball falling about 13 seconds. Use this time to find speed, acceleration, and distance.

32. A ping-pong ball of mass 2.3 g is released from a state of rest. When it reaches a speed of 2.0 m/s it has an acceleration of 7.6 m/s^2 downward. Suppose air resistance is modeled by $\mathbf{F}_{drag} = -k\mathbf{v}$. (a) Determine the ping-pong ball's terminal velocity. (b) Determine the time and impact speed if the ball is dropped from ceiling to floor, a distance of 3.0 m.

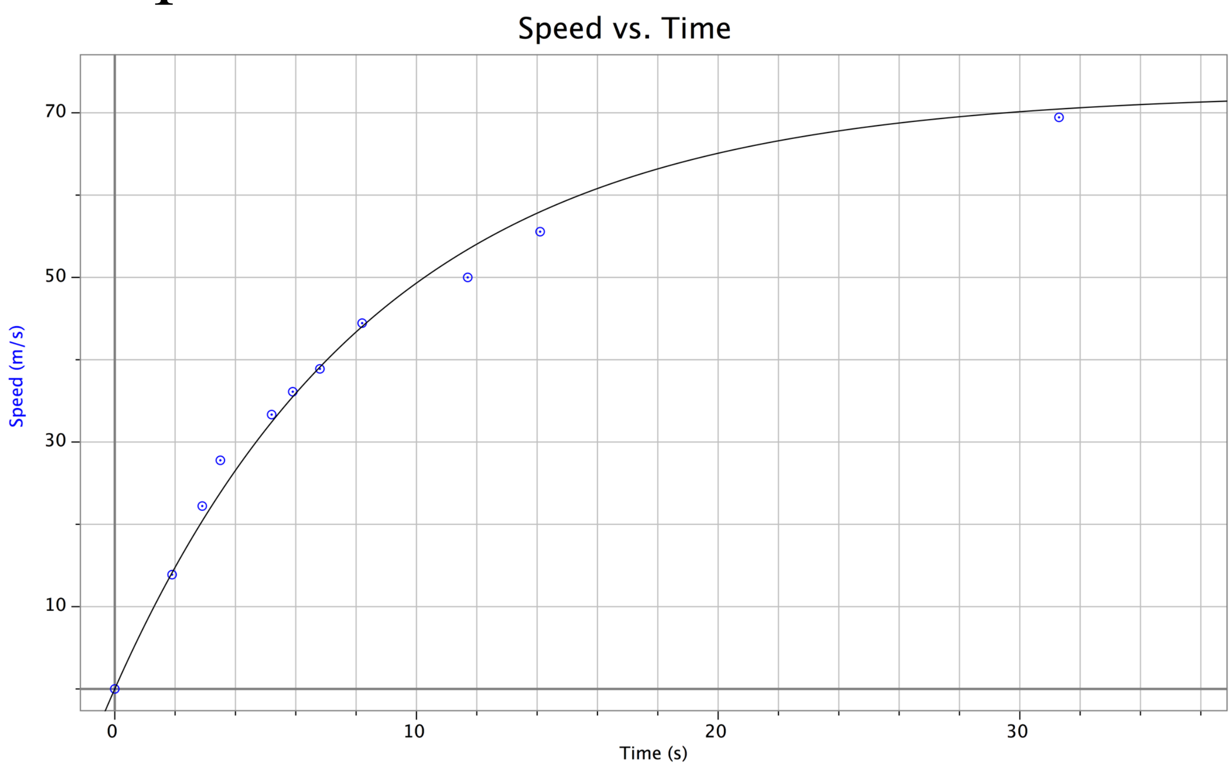
33. An object with initial speed v_0 slides to a stop. Model air resistance using $D = kv$. Derive an expression for the time to stop. Sketch a graph of speed vs. time. Derive expressions for initial and final acceleration.
Put all answers in terms of v_0, k, μ, and m.

34. Fill a balloon with air and measure its apparent mass. Use a ranging device to measure its motion when tossed into the air and allowed to fall. Note the terminal velocity and the acceleration when it reaches its maximum height. (a) Determine the mass of the balloon (and air inside it). (b) Find the force of buoyancy. (c) Determine the value of k in $D = kv$. (d) Use the initial upward velocity of the balloon to determine $v(t)$ – compare to an automatic curve fit.

35. A Tesla 3 Performance has mass 1860 kg and is said to have top speed 261 km/h and accelerate zero to 140 km/h in 6.8 s. Assume drag is proportional to speed.

(a) Find initial acceleration from rest.

(b) Determine the air resistance encountered at 100 km/h and the time to accelerate to that speed.



exponential curve &data (fastestlap.com)

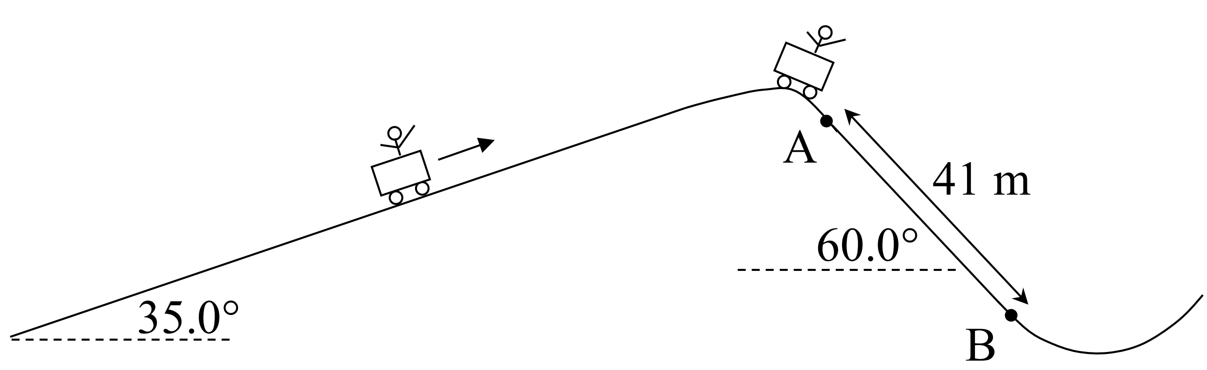
36. The 1997 Dodge Viper has mass 1547 kg and an engine that can produce a maximum driving force of 12.36 kN. Suppose drag is proportional to speed such that $k = 164$ Ns/m.

(a) Determine the initial acceleration of the Viper from rest. (b) Determine the maximum speed (i.e. terminal velocity). (c) Determine the time and final speed for the "standing ¼ mile". Compare these results to the actual data below taken from a car magazine:

Time (s)	Speed (m/s)
0.0	0.00
1.7	13.4
2.4	17.9
3.1	22.4
4.0	26.8
4.9	31.3
5.9	35.8
7.4	40.2
8.7	44.7
10.6	49.2
12.5	53.6
14.7	58.1
18.3	62.6
22.5	67.1
28.2	71.5
¼ mile data: 12.2 s, 52.8 m/s	Top speed: 79.1 m/s

37. A book is placed on a board tilted at an angle. Given the coefficients of static and kinetic friction and the value of the angle, solve for: (a) the force applied parallel to the surface necessary to prevent the book from moving, and (b) the acceleration of the book if it is released on the ramp.

38. A rollercoaster ride is shown in the diagram below. The mass of the car and rider is 700.0 kg and the coefficient of friction is 0.0500. (a) Determine the force that must be applied to the car as it is pulled up the hill at a constant speed of 1.00 m/s. (b) The car is released at point A with speed 1.00 m/s – find the speed at point B.



39. A fan cart of mass m and thrust T rolls on a surface with coefficient of friction μ. Determine the greatest additional mass the cart can carry up a ramp of inclination θ.

40. A snow skier glides with constant velocity on a slope inclined at an angle of 5.0°. The skier then encounters a ski trail with an incline of 30.0°. Determine the rate of acceleration.

41. Suppose the skier from the previous problem has mass 75 kg and uses his poles to push horizontally with a force of 80.0 N. Determine his acceleration on the steeper slope.