Chapter 7 - Potential Energy and Energy Conservation

Physics 206

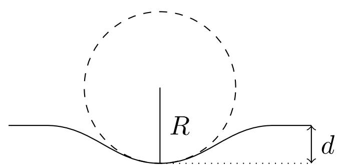
For any problems where you are given a variable/symbol and a value for that variable, make sure to solve the problem symbolically first. Your final answer should then only contain the variables that you are given values for in the problem, constants that appear on the equation sheet and numbers like 2 or π.

Group 1 Problems:

Problem 1: A 1600 kg car is driving up a hill that has a top 17.0 m above its bottom. The car is moving 22.0 m/s at the bottom and 14.0 m/s at the top. If the car's engine does 80.0 kJ of work as it goes up the hill, what was the work done by all other non-conservative forces?

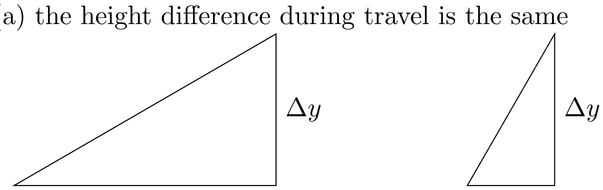
Problem 2: In the World's Strongest Man competition, the contestants have to pull a semi-truck with mass m up a slight incline. They have to pull the truck a distance d and the incline is θ above the horizontal. Assume the truck starts and ends at rest and that the trucks wheels are free to rotate so frictional forces are negligible.
(a) What is the work done by the contestants?
(b) What is the average power exerted by the contestants if they pull the truck that distance in one minute?

Problem 3: A 68.0 kg skier is moving horizontally with a speed of 7.75 m/s. They then encounter a small dip which has an effective radius of $R = 14.0$ m at the bottom. The bottom of the dip is $d = 1.45$ m lower than the starting height. What is the normal force acting on the skier at the bottom of the dip? You can ignore the effects of friction in this problem.

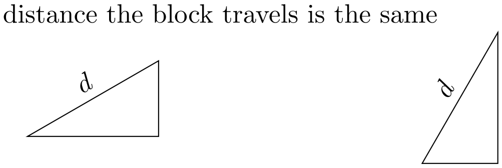


Problem 4: Block 1 and block 2 have the same mass, m, and are released from the top of two inclined planes of the same height making 30 and 60 degree angles with the horizontal direction, respectively. The coefficient of friction is the same in both inclines. Which of the blocks is going faster when it reaches the bottom if

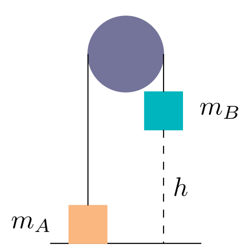
(a) the height difference during travel is the same



(b) the distance the block travels is the same



Problem 5: In the Atwood's Machine below, m_A is in contact with the table and both masses are released from rest. If $m_B > m_A$, use energy methods (not Newton's laws) to find the speed of m_B when it hits the table.



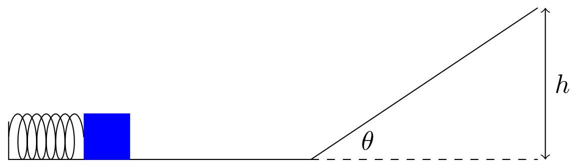
Group 2 Problems:

Problem 6: Imagine that there is a potential energy function $U(x, y) = x^2y + 8x - 36y$. Find all positions where the magnitude of the net force is zero.

Problem 7: A human cannonball is launched by releasing a strong, compressed spring and having it push a platform which in turn pushes the performer. The person is 75.0 kg and the spring is going to decompress by 2.25 m and launch the person at a 45.0 degree angle. In order to land in the net, the performer needs to leave the end of the cannon moving 15.0 m/s. What does the force constant of the spring have to be?

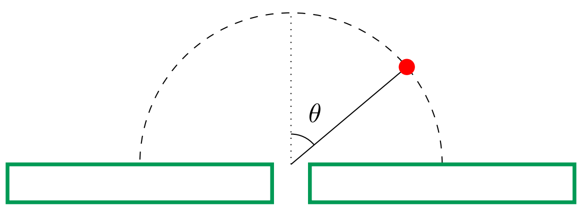
Problem 8: A box is given a speed v_0 at the bottom of an incline. The incline has an angle of θ relative to the horizontal, and the box comes to rest after traveling a distance d. What is the coefficient of friction between the box and the ramp if the average energy dissipated by friction was E?

Problem 9: A box of mass m is held against a spring of constant k and is initially compressed by a distance x. If the block is released from rest and flies off the end of a ramp that has a height h and angle θ, what is the maximum height that the block will reach?

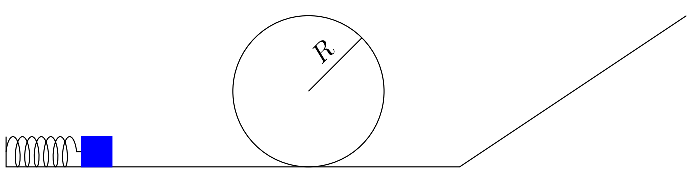


Problem 10: A box of mass $M = 12.0$ kg is placed on a perfectly smooth surface at the origin with a ramp 10.0 m in front of it. A force of $F(x) = 5x + 3$ N is applied horizontally to the box in the direction of the ramp for the entire 10.0 m. The ramp has a kinetic friction coefficient of $\mu_k = 0.200$, an angle $\theta = 15.0$ degrees, and is very long.
a) Find the speed of the box right before it transitions to the ramp.
b) Draw a free-body diagram of the system when the box has reached the ramp.
c) How far up the ramp does the box travel?
d) Find the work done by friction through the distance between the bottom of the ramp and where the box has zero velocity.

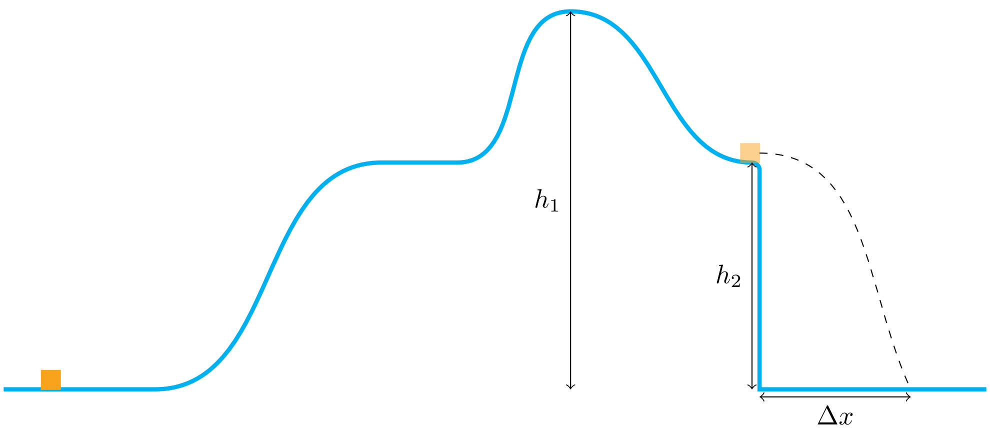
Group 3 Problems:
Problem 11: A small object of mass m moves in a semi-circular path between two bumper walls (essentially very wide springs - think of pinball obstacles) on a rough table. The object is held to a path which has a radius R by a very light, rigid rod. To start, the object was compressed on the left wall by X cm and then released at $t = 0$. When it reached the right wall, the wall only compresses $(4X/5)$ cm. Assume both walls have an effective spring constant of k. Notice that the picture below is a top down view on the table. Nothing is changing height.
(a) At what time does the object come to rest? (Assume that the interaction time with the springs is effectively instantaneous)
(b) At what θ does this occur (relative to the vertical shown below)? What direction was the ball moving at this time?



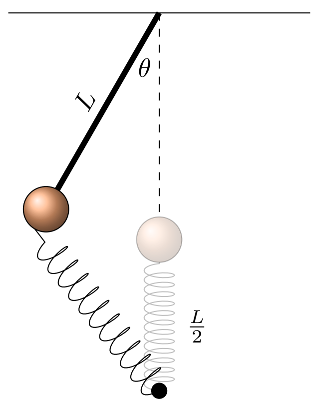
Problem 12: A block of mass m is held compressed against a spring of constant k and released from rest.
(a) What minimum compression of the spring is necessary so that the block just barely clears the top of the loop of radius R?
(b) If the block is initially held at this compression, is released, clears the loop and encounters a rough ramp μ_k that makes an angle theta with the horizontal, how far up the ramp does the block travel before coming to rest?



Problem 13: The figure below shows an icy surface. What is the minimum distance (Δx) from the edge of the cliff that the box will land, if the box is pushed so that it stays in contact with the entire surface until it reaches the edge?



Problem 14: A pendulum is suspended from the ceiling and attached to a spring fixed to the floor directly below the pendulum support (see the figure below). The mass of the pendulum bob is m, the length of the pendulum is L, and the force constant is k. The natural length of the spring is $L/2$ and the distance between the floor and ceiling is $1.5L$. The pendulum is pulled aside so that it makes an angle θ with the vertical and is then released from rest. Obtain an expression for the speed of the pendulum bob as the bob passes through a point directly below the pendulum support.



Problem 15: In the figure below, Box A is 25.0 N, Box B is 35.0 N and Box C is 45.0 N. The coefficient of kinetic friction between the boxes and the surface is always 0.375. The plane makes and angle of 20.0 degrees with the horizontal. If Block C starts 1.50 m above the ground, how fast is it moving when it gets to the ground? Assume that the blocks are all able to move that distance without hitting the pulleys.