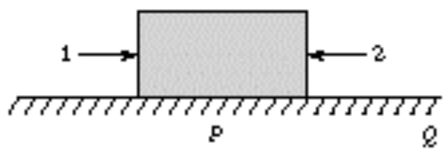
Problem Solving Kinetic Energy and Work

Challenge Problems

Problem 1:

Two people push in opposite directions on a block that sits atop a frictionless surface (The soles of their shoes are glued to the frictionless surface). If the block, originally at rest at point P, moves to the right without rotating and ends up at rest at point Q, describe qualitatively how much work is done on the block by person 1 relative to that done by person 2?



Problem 2:

An inextensible rope hangs from the ceiling of a gym. Jamal, who has mass M, grabs the rope and climbs to a height h. Assume that the acceleration of gravity is g. The following questions refer to a time period that begins when Jamal is standing at rest on the ground, and ends when he is hanging motionlessly on the rope at height h. You can write the answers without explanation.

(a) How much work is done on Jamal by gravity?

(b) How much work is done on Jamal by the rope?

Problem 3: Object Sliding on Inclined Plane and Rough Surface

An object of mass $m = 4.0\,\mathrm{kg}$, starting from rest, slides down an inclined plane of length $l = 3.0\,\mathrm{m}$. The plane is inclined by an angle of $\theta = 30^{\circ}$ to the horizontal. The coefficient of kinetic friction $\mu_{\mathrm{k}} = 0.2$. At the bottom of the plane, the object slides along a rough horizontal surface with a coefficient of kinetic friction $\mu_{\mathrm{k}} = 0.3$ until it comes to rest. The goal of this problem is to find out how far the object slides along the rough surface. You will need to assume that the object does not change speed at the bottom of the plane, when the object begins to more horizontally.

a) Describe how you will model this motion. Include a free body diagram for the object while it is on the inclined plane and while it is sliding along the horizontal surface. Explain whether Newton's Second Law or the Work-Kinetic Energy Theorem provides an easier approach to this problem.

b) What is the work done by the friction force while the mass is sliding down the inclined plane? Is this work positive or negative?

c) What is the work done by the gravitational force while the mass is sliding down the inclined plane? Is this work positive or negative?

d) What is the kinetic energy of the mass just at the bottom of the inclined plane?

e) What is the work done by the friction force while the mass is sliding along the ground? Is this work positive or negative?

f) How far does the object slide along the rough surface?

Problem 4: Work-kinetic energy object sliding on inclined plane and rough surface

An object of mass $m = 4.0\,kg$, starting from rest, slides down an inclined plane of length $l = 3.0\,m$. The plane is inclined by an angle of $\theta = 30^0$ to the ground. The coefficient of kinetic friction $\mu_k = 0.2$. At the bottom of the plane, the mass slides along a rough surface with a coefficient of kinetic friction $\mu_k = 0.3$ until it comes to rest. The goal of this problem is to find out how far the object slides along the rough surface.

a) Describe how you will model this motion. Include a free body diagram for the object while it is on the inclined plane and while it is sliding along the horizontal surface. Explain whether Newton's Second Law or the Work-Kinetic Energy Theorem provides an easier approach to this problem.

b) What is the work done by the friction force while the mass is sliding down the inclined plane? Is this positive or negative?

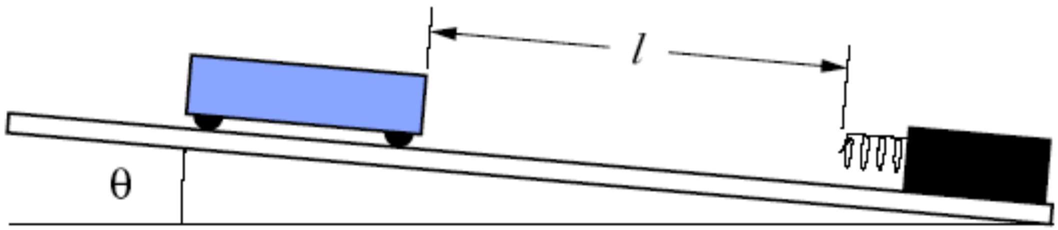
c) What is the work done by the gravitational force while the mass is sliding down the inclined plane? Is this positive or negative?

d) What is the kinetic energy of the mass just at the bottom of the inclined plane?

e) What is the work done by the friction force while the mass is sliding along the ground? Is this positive or negative?

f) How far does the object slide along the rough surface?

Problem 5:

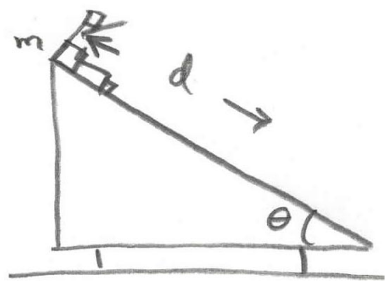


A cart of mass M rolls down a track inclined at an angle θ. The cart starts from rest a distance l up the track from a spring, and rolls down to collide with the spring.

1. Assuming no non-conservative work is done, what is the speed of the cart when it first contacts the spring? (Express your answer in terms of the given variables and the gravitational acceleration g.)

2. Suppose the spring has a force constant k. What is the peak force compressing the spring during the collision?

Problem 6: Slide (Energy, Force, and Kinematics)



A child's playground slide is $d = 5.0m$ in length and is at an angle of $\theta = 2.0 \times 10^1 deg$ with respect to the ground. A child of mass $m_b = 2.0 \times 10^1 kg$ starts from rest at the top of the slide. The coefficient of sliding friction for the slide is $\mu_k = 0.2$.

a) What is the total work done by the friction force on the child?

b) What is the speed of the child at the bottom of the slide?

c) How long does the child take to slide down the ramp?