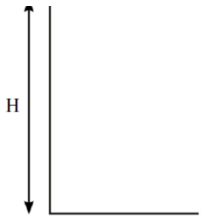
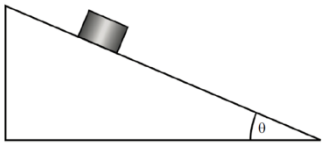
Questions for Module # 13

Q.1 A rock of mass m falls down a cliff of height H. The rock has initial velocity v_0, directed horizontally. Assume no air resistance. Solution

a. Find the position of the rock as a function of time.
b. What is the velocity of the rock when it touches the ground?



Q.2 Consider a block of mass m sliding down a frictionless ramp at an incline θ. Find the velocity of the block at time t if the block is stationary at $t = 0$. Use F=ma for this question. Solution

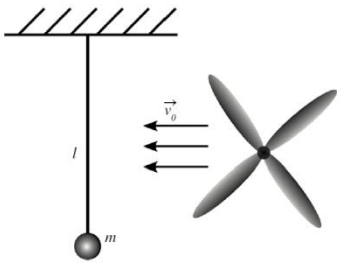


Q.3 A particle with initial mass m_0 and initial velocity v_0 begins losing mass according to the equation $m(t) = m_0 e^{-\alpha t}$ where α is constant. If there are no external forces, find an expression for the velocity. Solution

Q.4 A ball of mass m is thrown with initial velocity v_0 at an angle of 45° from the horizontal. Solution

a. Assuming no air resistance, find the trajectory of the ball $y(x)$.
b. Assuming linear resistance bv, find the trajectory of the ball $y(x)$.

Q.5 Imagine a pendulum consisting of a spherical mass m which is placed in front of a large fan. At $t = 0$, the fan begins blowing air at a velocity v_0. Find the equation of motion for the mass considering only quadratic air resistance. Solution



Q.6 A cart is moving on a horizontal surface with initial velocity v_0 subject to a drag force of the type $f(v) = -cv^{\frac{3}{2}}$. Find the speed of the cart as a function of time. Solution

Q.7 Consider two particles of mass m_1 and m_2. Find the amount of kinetic energy loss during an inelastic collision if the particles are initially traveling at $\vec{v}_1$ and $\vec{v}_2$. Considering the case when $m_1 = m_2 = m$, can this energy loss be ignored in any situation? Solution

Q.8 Analyze the motion of a rocket starting with initial mass m_0, which accelerated from rest. Obtain the momentum versus mass, $p(m)$ and find the mass for which you obtain the maximum momentum. What was the mass of the fuel consumed? Find the maximum momentum. Solution

Q.9 A rocket is tethered to a pole such that it moves in a circular orbit At $t = 0$, the rocket begins burning fuel in a way that decreases its mass in accordance with the equation $m(t) = m_0 e^{-t\lambda}$.

If the initial rope length is R, initial mass is m_0, and initial velocity is v, find an expression for the rope length, as a function of time, that keeps the angular momentum constant. Assume the rocket thrust is such that the rocket's velocity increases as $v(t) = v + \alpha t$.

Solution

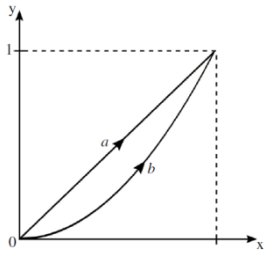
Q.10 Evaluate the line integral for the work done by the following forces on both paths shown. Determine if each force is conservative.

Path a is along the line $y = x$

Path b is along the line $y = x^2$

a. $F_1 = (y^2, x)$

b. $F_2 = (2x, y)$



Solution

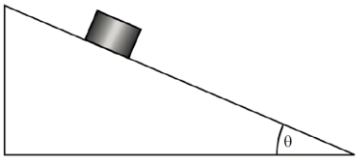
Q.11 A skier, starting with a velocity v_0, slides down a frictionless ski jump ramp Find,

a. The maximum speed of the skier.

b. The speed of the skier at the end of the ramp.

Solution

Q.12 Consider a block of mass m sliding down a frictionless ramp at an incline θ.



Use energy conservation to find the velocity of the block at time t if the block is stationary at t=0.

Solution