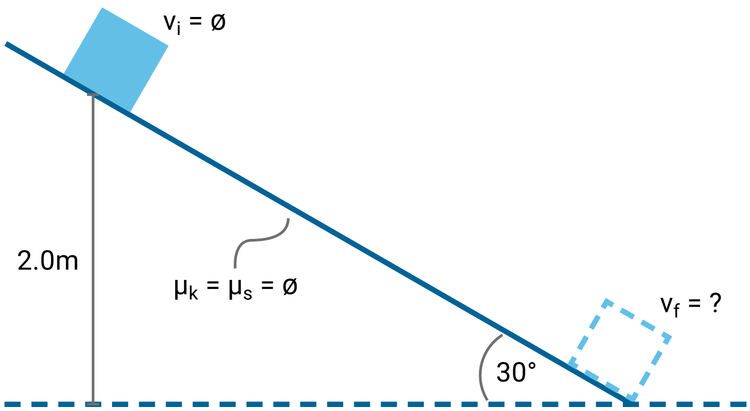
Find the mistakes

Related video: *16 – Popular mistakes with conservation of energy*

For each of the following problem solutions, find the mistake(s).

a) Question: v_f=?



Suggested solution:

1. $E_f = E_i + \text{Change}$
2. $KE_f + PE_f = KE_i + PE_i + W_f + W_g + W_N$
3. $0.5\ mv_f^2 + 0 = 0 + mgh + 0 + F_g \cdot 2.0/\sin(30°) \cdot \cos(60°) + 0$
4. $0.5\ v_f^2 = gh + g \cdot 2.0/\sin(30°) \cdot \cos(60°)$
5. $v_f^2 = 2 \cdot (19.62 + 19.62)$
6. $v_f = \sqrt{(2 \cdot (19.62 + 19.62))} = 8.9$ m/s

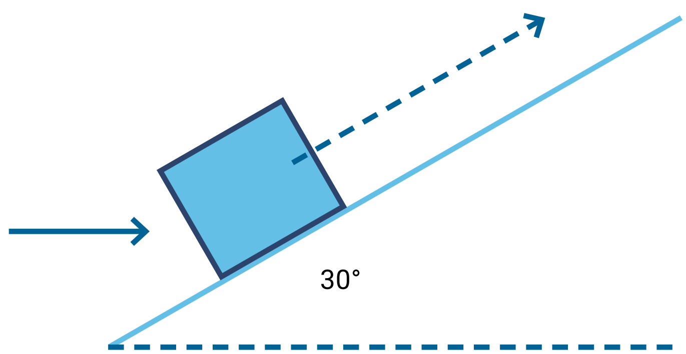
b) Question: (Problem 3) A ball is thrown out of the window of a building. It leaves the window horizontally with a speed of 2.0 m/s. It hits the street below at a speed of 15 m/s. At what height was the ball thrown from? Ignore air-friction.

Suggested solution:

1. $\Delta KE = \Delta U$
2. $½ \, mv_f^2 - ½ \, mv_i^2 = mgh_f - mgh_i$
3. $½ \, v_f^2 - ½ \, v_i^2 = 0 - gh_i$
4. $h_i = ½(v_f^2 - v_i^2)/g = -11 \text{ m}$

c) Question: (Problem 4) A 1.5 kg box, starting from rest, is pushed a distance of 4.0 m up a hill. The slope of the hill is 30. degrees. The pushing force has a magnitude of 50. N. It acts horizontally. In addition, there is a friction of 2.0 N.

What is the speed of the box after the 4.0 m?



Suggested solution:

1. $E_f = E_i + \text{Change}$
2. $KE_f + PE_{gf} +$ ~~PE_{Ef}~~ $= KE_i + PE_{gi} +$ ~~PE_{Ei}~~ $+ W_f + W_F$
3. $½ \, mv_f^2 + mgh_f = 0 + 0 + \mathbf{f} \times \mathbf{s} + \mathbf{F} \times \mathbf{s}$
4. $½ \, mv_f^2 + mg \cdot s \cdot \sin(30°) = + f \cdot s \cdot \sin(180°) + F \cdot s \cdot \sin(30°)$
5. $½ \, mv_f^2 + 29.4 \text{ J} = -0 \text{ J} + 100 \text{ J}$
6. $½ \, mv_f^2 = -0 \text{ J} + 100 \text{ J} - 29.4 \text{ J} = 70.6 \text{ J}$
7. $v_f = \sqrt{(2/1.5\text{kg} \cdot 70.6 \text{ J})} = 9.7 \text{ m/s}$

d) Question: (Problem 6) Two unknown solutions, initially at room temperature, are mixed. After the solutions react with each other, the temperature in the calorimeter rises by 3.2 °C. The total mass of the two solutions together is 420 grams. Find the change in enthalpy during the reaction.

Assuming that both solutions contain mostly water and that the mass of the solutes is small, use the specific heat capacity of water.

Suggested solution:

1. $Q = mcT = 0.42 \text{ kg} \cdot 4.186 \cdot (3.2 + 273.15)°K = 485 \text{ J}$
2. $\Delta H = Q = 485 \text{ J}$

e) Question: (Problem 7) While operating at a constant temperature, a heat engine produces 6.2 kJ of useful work and releases 12.0 kJ of heat to the environment. Determine the efficiency of that heat engine.

Suggested solution:

1. $E_f = E_i + W + Q$
2. Constant temperature = No change in internal energy: $E_f = E_i$
3. Efficiency = W_{out}/Q_{in} = - 6.2 kJ/ 12.0 kJ = - 52%.

f) Question: (Problem 11) In a horizontal toy-cannon, a small plastic ball of mass m is accelerated by a compressed spring with a spring constant k. The spring is initially compressed by a distance x. Find the kinetic energy when the ball leaves the cannon and the work done by the spring.

Note: This problem has no numbers. Find the solution as a function of m, k and x.

Suggested solution:

1. $W = +\int_{-x}^{0} k \cdot s \, ds = [0.5 \cdot k \cdot s^2]_{-x}^{0} = +0.5 \cdot kx^2$
2. Final Energy = Initial Energy + Change
3. $KE_f + PE_f = KE_i + PE_i + W$
4. $KE_f + 0 = 0 + 0.5 \cdot kx^2 + 0.5 \cdot kx^2$
5. $KE_f = 0.5 \cdot kx^2 + 0.5 \cdot kx^2 = kx^2$