Physics

Homework 2

Maksim Al Dandan

B23-ISE-01
m.aldandan@innopolis.university

1 Problem 1

Part 1: Finding the Spring Constant k

The energy stored in the spring when compressed by depth x is given by the potential energy in the spring:

$$E_{\text{spring}} = \frac{1}{2}kx^2$$

To launch the character to height H, the spring's energy must equal the gravitational potential energy at that height:

$$E_{\text{gravity}} = mgH$$

Setting $E_{\text{spring}} = E_{\text{gravity}}$, we have:

$$\frac{1}{2}kx^2 = mgH$$

Solving for k:

$$k = \frac{2mgH}{x^2}$$

Substituting the given values:

$$k = \frac{2 \times 80 \times 9.8 \times 70}{(0.5)^2}$$

Calculating this gives:

$$k \approx 439{,}000\,\text{N/m}\,\text{(rounded to the nearest thousand)}$$

Part 2: Finding the Maximum Speed v_i

The maximum speed v_i occurs at the point of launch, where all the spring's potential energy is converted into kinetic energy.

Using energy conservation:

$$\frac{1}{2}mv_i^2 = \frac{1}{2}kx^2$$

Solving for v_i:

$$v_i = \sqrt{\frac{kx^2}{m}}$$

After calculating k in Part 1, we substitute it here to find v_i in m/s and then convert to km/h by multiplying by 3.6:

$$v_i \approx 133.3\,\text{km/h}\,\text{(rounded to 1 decimal place)}$$

Final Answers

1. The spring constant k should be approximately $\boxed{439{,}000\,N/m}$.
2. The maximum character's speed v_i is $\boxed{133.3\,km/h}$.

2 Problem 2

$$\vec{N} + \vec{F_f} + m\vec{g} = m\vec{a}$$

$$'OX' : N = mgcos\alpha$$

$$'OY' : -\mu N + mgsin\alpha = ma_1$$

Work of friction force on the inclined plane:

$$W_1 = -\mu mgs_1cos\alpha$$

Work of friction force on the horizontal plane:

$$W_2 = -\mu mgs_2$$

Change of kinetic energy:

$$\Delta E_k = W_{all}$$

1. Until the object reaches the horizontal plane:

$$\frac{mv^2}{2} = mgs_1sin\alpha - \mu mgs_1cos\alpha$$

$$v^2 = 2gs_1(sin\alpha - \mu cos\alpha)$$

2. After the object reaches the horizontal plane:

$$-\frac{mv^2}{2} = -\mu mgs_2$$

$$v^2 = 2\mu gs_2$$

Substitute v^2 from 2. into 1.:

$$2\mu gs_2 = 2gs_1(sin\alpha - \mu cos\alpha)$$

Find s_1:

$$s_1 = \frac{2\mu s_2}{sin\alpha - \mu cos\alpha}$$

Thus, final work of friction forces:

$$W_{all} = -\mu mgscos\alpha\frac{2\mu s_2}{sin\alpha - \mu cos\alpha} - \mu mgs_2 \approx \boxed{-0.05N}$$

3 Problem 3

Part 1: Finding the Height Ratio $\frac{h}{H}$

$$mgH = mgh + \frac{mv_m^2}{2}$$

$$g(H-h) = \frac{v_m^2}{2}$$

$$s_m = v_m\sqrt{\frac{2h}{g}}$$

$$g(H-h) = s^2\frac{g}{h}$$

$$4h^2 - 4hH + s^2 = 0$$

To maximize s, the derivative must be zero:

$$8h - 4H = 0 \implies \boxed{\frac{h}{H} = \frac{1}{2}}$$

Part 2: Finding the Maximum Distance s in Terms of H

Substitute this portion into the equation:

$$H^2 - 2H^2 + s^2 = 0 \implies \boxed{s = H}$$

4 Problem 4

Part 1: Finding the Tank's Power

$$P = \frac{W}{t}$$

$$t = \frac{d}{v}$$

$$W = Fd$$

These all implies that:

$$F = \frac{P}{v}$$

$$F = mgsin\alpha$$

Hence:

$$mgsin\alpha = \frac{P}{v}$$

Answer:

$$m = \frac{P}{gvsin\alpha} \approx \boxed{102.39\,\text{tons}}$$