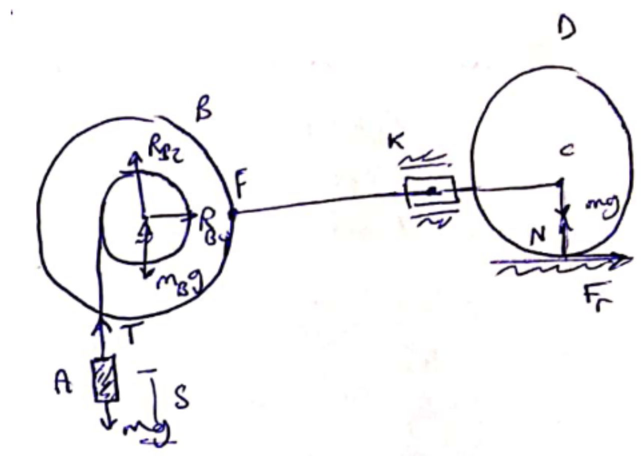
Task 1:



Research objects: System of 4 bodies

-Object A: rectilinear motion

-Pulley B: Rotational motion

-Piston K: rectilinear motion

-Object D: rotational and translatory motion

Conditions:

Initially the system is at rest (all velocities are 0)

By the effect of the force G, after t time, object A will go down by s distance having a velocity of v_A, All other objects will follow.

Force Analysis:

G_A, G_B, G_D

T, R_{B_y}, R_{B_z}

N_D, F_r

Solution:

Energy:

$T_2 - T_1 = \sum_i A_i$

$T_1 = 0$ (No motion of the system at the start)

$T_2 = T_A + T_B + T_D + T_K$

$T_A = 0.5 m_A v_A^2$

$T_B = 0.5 I_{B_x} w_B^2 = \frac{m_B i_{B_x}^2 v_A^2}{2 r_B^2}$

$T_K = 0.5 m_K v_K^2 = \frac{0.5 m_K v_A^2 R_B^2}{r_B^2} = 0$ (Mass of K is negligeable)

$T_D = 0.5 m_D v_C^2 + 0.5 I_{D_x} w_D^2 = 0.5 m_D v_A^2 \frac{R_B^2}{r_B^2} + 0.5^2 m_D R_D^2 v_A^2 \frac{R_B^2}{r^2 R_D^2}$

Work:

$A_A = m_a g s$

$A_B = 0$

$A_K = 0$

$A_D = m_D g 0 + A(F_r) + \delta N \Phi_D$

$A(F_r) = 0$

$\Phi_D = \frac{r_B x_D}{R_B R_D}$

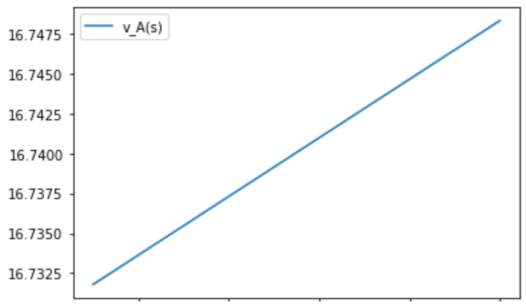
After substituting all the works found back in the equation $T_2 - T_1 = \sum_i A_i$ We will have an equation containing $v(s)$ which we will use for the plot:

```
import numpy as np
import matplotlib.pyplot as plt
import sys
from math import sin, cos, tan, sqrt, asin, acos,pi, exp
import matplotlib.pyplot as plt

m_a = 1
m_b = 3
m_d = 20
R_b = 20
R_d = 20
i_bx = 18
r_b = 16
fk = 64
phi = 0.6
g = 9.8

ground_height = 10
v_a = []
s_all = []
for i in range(0,ground_height):
    s = ground_height - i
    s_all.append(s)
    v_a_2 = (m_a*s + m_d*g*((fk+R_b-sqrt(fk**2 - R_b**2))))
    v_a_2 /= (0.5*m_a+0.5*m_b*i_bx/r_b**2 + 0.5*m_d*R_b**2/r_b**2 + 0.25*m_d*R_b**2/((R_d**2)*(r_b**2)))
    v_a.append(sqrt(v_a_2))

plt.plot(s_all,v_a, label="v_A(s)")
plt.legend()
plt.show()
```



Second part:

If the masses are not neglected that will lead to having forces in the center of masses of the links and the mass of the piston which will lead to take into consideration the pressure on the surface of the slider and the masses of the links will lead to work in the equations which will make it harder solve as $A_k \neq 0$ and there will be more unknowns than the number of equations.