INSA INSTITUT NATIONAL DES SCIENCES APPLIQUÉES LYON

SCAN 1st

Mechanics test 2

Friday, 8th April 2022 – Duration: 1h30

2-page personal formula sheet authorised.

Exercise 1:

The 2-kg collar in Figure 1 slides along the guide rod AB with negligible friction. The free length of the spring attached to the collar is $L_0 = 1.2m$, and its stiffness is $k = 60N/m$.

1 - If the collar is moving down the rod with the speed $v_A = 4m/s$ when it is at A, determine its speed when it is at B.

2 – Determine the work done by the weight between A and B

3 – Determine the power generated by the weight of the collar at point B.

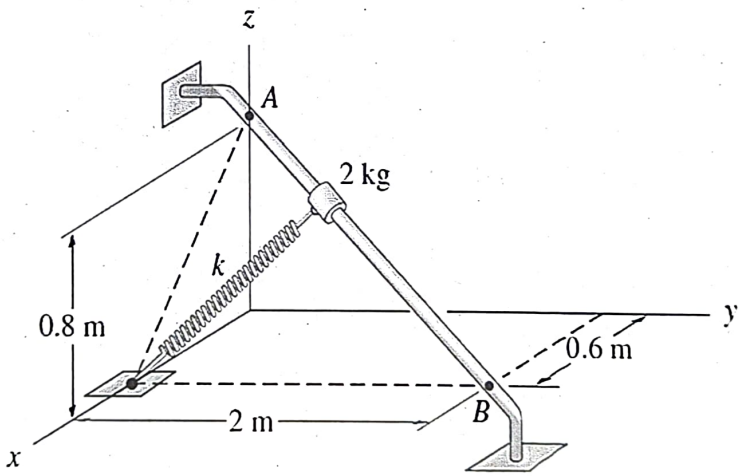

Figure 1.

Exercise 2:

The telephone cable spool in Figure 2 has a total mass M and is held at rest on an incline at an angle α from the horizontal. The cable holding the spool is wound around the inner hub of the spool and attached to the support at B as shown in the figure. It is assumed that the centre of gravity of the spool is located at G, centre of the spool.

1- Represent the free-body diagram of the spool and identify all the forces acting on it

2- Assuming static equilibrium, determine all the forces acting on the spool in terms of M, g, R, r and α

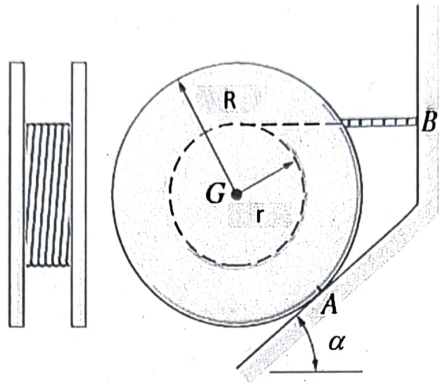

Figure 2.

Exercise 3:

The 1-kg piston in Figure 3 is supported by a spring of stiffness 770 N/m, a dashpot of damping coefficient c=27 N.s/m acts in parallel with the spring. A fluctuating pressure $p = 4300\sin(30t)$ (Pa or N/m²) acts on the piston head of surface area $S = 5.210^{-2}\,\text{m}^2$. Friction is neglected.

1 – Find the natural frequency of the undamped system, the damping factor ζ and the natural frequency of the damped system.

2 – Determine the time-varying force acting on the piston head and the corresponding steady-state displacement as a function of time.

3 – Bonus: Deduce the maximum force transmitted to the base for steady-state conditions.

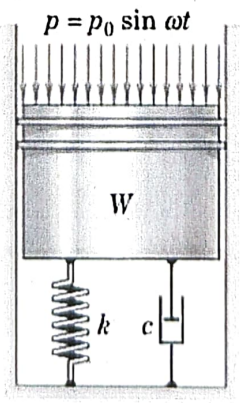

Figure 3.

Exercise 4:

A particle of mass m is thrown with speed v_0 at an angle α with respect to the horizontal. For the range of speeds in this example, it can be assumed that the resistance of air is proportional to speed and opposite to the velocity direction at all time, i.e., $\mathbf{F}_{air} = -c\,\mathbf{v}$ where c is constant (known) and $\mathbf{v}$, the velocity vector of the particle.

1 – Show that there exists a limit in the horizontal distance that can be reached and give its expression

2 – What happens once the particle has reached this limit?