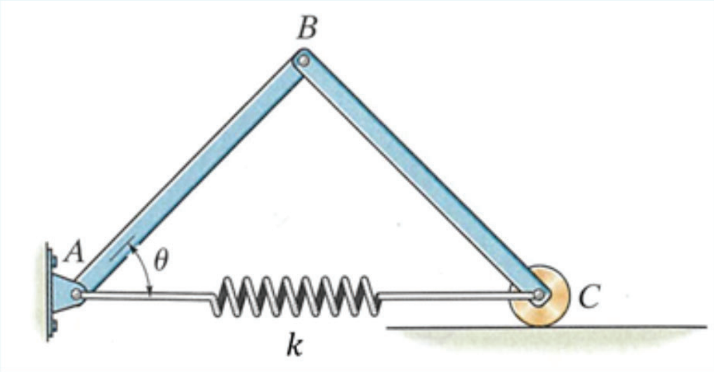
Tidy question | Question tests & deployed versions

Question A

This question has FOUR parts: (a), (b), (c), and (d)



The two 12-kg slender rods are pin connected and released from rest at the initial position $\theta = 60°$. The spring has an unstretched length of 1.5 m.

Given $AB = BC = 2.0$ m and the stiffness of the spring $k = 20$ N/m.

(a) Derive the relationship between the angular velocities (magnitude and direction) of links AB and BC at the position $\theta = 30°$. Enter the ratio of the angular velocity of rod AB to that of rod BC below by taking both their magnitudes and directions into consideration:

$\omega_{AB} =$ ______ $\cdot\, \omega_{BC}$

(b) Find the total change in the gravitational potential energy (ΔV_g) of the system when the system travels from its initial position at $\theta = 60°$ to the position $\theta = 30°$. Consider the standard convention, which is positive for energy gain and negative for energy loss.

______ **J**

(c) Find the change in the elastic energy (ΔV_e) of the spring when the system travels from its initial position at $\theta = 60°$ to the position at $\theta = 30°$. Consider the standard convention, which is positive for energy gain and negative for energy loss.

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(d) Determine the angular velocity (magnitude only) of rod BC when the system is at the position $\theta = 30°$.

______ **rad/s**

End of Question A

Question B

This question has FOUR parts: (a), (b), (c), and (d)

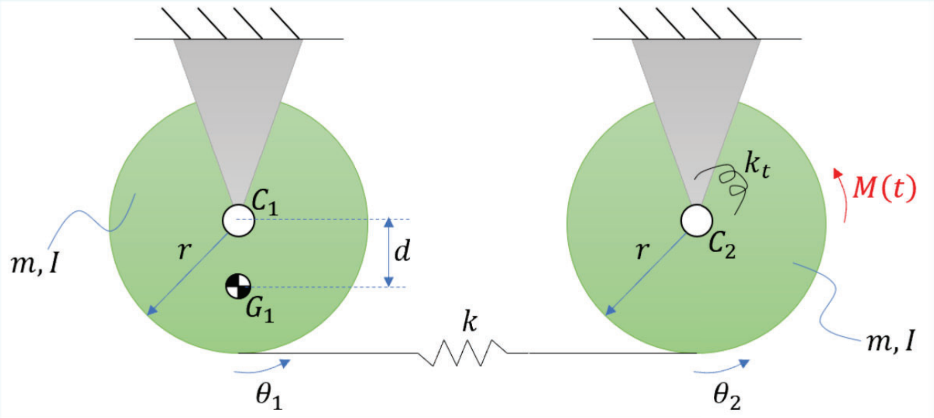
The system shown in the figure below is composed of two discs.

- The disc on the left has mass m = 10 kg, radius r = 1.9 m and moment of inertia I = 13.63 kg·m^2 about its centre C_1. Its centre of mass G_1 is located at a distance d = 0.4 m from its centre C_1. The angle θ_1 (positive CCW) describes the rotation of the disc about its centre C_1.

- The disc on the right has the same mass m = 10 kg, radius r = 1.9 m and moment of inertia I = 13.63 kg·m^2 about its centre C_2. However, its centre of mass is coincident with its centre C_2. The angle θ_2 (positive CCW) describes the rotation of the disc about its centre C_2.

The discs are connected by a flexible cable, which behaves as a spring of stiffness k = 103 N/m. The disc on the right is also connected to the ground by a torsional spring of stiffness k_t = 58 N·m/rad.

An external harmonic moment $M(t)$ = M_0·cos(ωt) is applied to the mass on the right. The moment has an amplitude M_0 = 0.89 N·m and a frequency ω = 0.26rad/s.



When θ_1 = 0 and θ_2 = 0, the spring is unstretched and the centre of gravity G_1 of the first disc is vertically aligned below the disc's centre C_1 (as shown in the figure).

Answer all the following parts (a, b, c, and d)

a) In your PDF solutions, show that the nonlinear equations of motion of the system in y_1 and y_2 are the following:

$$13.63\cdot\ddot{\theta}_1 + 371.8\cdot\theta_1 - 371.8\cdot\theta_2 + 39.24\cdot\sin(\theta_1) = 0$$

$$13.63\cdot\ddot{\theta}_2 - 371.8\cdot\theta_1 + 429.8\cdot\theta_2 = M(t)$$

b) In your PDF solutions and starting from the equations of motion given in part (a), show that the position $\theta_1 = 0$ rad and $\theta_2 = 0$ rad is a stable equilibrium position

c) In your PDF solutions, linearise the equation of motion given in part (a) around the equilibrium position given in part (b). Then find and report here the numerical values of the Mass and Stiffness matrices

M =

kg·m^2	kg·m^2
kg·m^2	kg·m^2

K =

N·m/rad	N·m/rad
N·m/rad	N·m/rad

d) Find the steady state amplitude of vibration for θ_1 and θ_2 **in degrees**.

- Steady state vibration amplitude of θ_1 = degrees
- Steady state vibration amplitude of θ_2 = degrees

End of Question B

End of mock exam