ME101 Engineering Mechanics
(Tutorial 4) Virtual Work and Potential Energy

Time: 8:00- 8:55 am **Date: 06/02/2013**

Note: Each question carries 10 Marks

Section 1 (To be discussed by the tutor)

Q. No. 1 The spring of constant k is unstretched when θ=0 (Fig. 1). Derive an expression for the force P required to deflect the system to an angle θ. The mass of the bars is negligible.

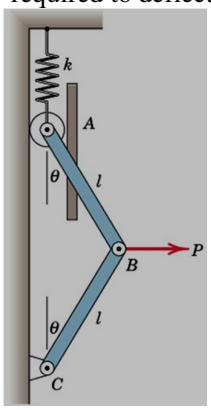


Fig. 1

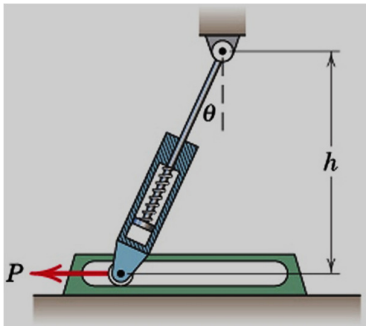
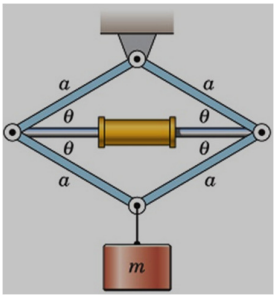


Fig. 2

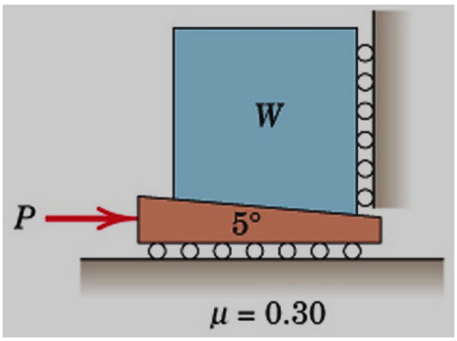
Q. No. 2 Determine the force P required to maintain equilibrium of the spring-loaded mechanism for a given angle θ shown in Fig. 2. The spring has a stiffness k and is uncompressed at θ=0.The mass of the parts may be neglected.

Section 2: Tutorial Questions

Q. No. 3 The hydraulic cylinder (Fig. 3) is used to spread the linkage and elevate the load m. For the position shown determine the compression C in the cylinder. Neglect the mass of all parts other than m.



(Fig. 3)



(Fig.4)

Q. No. 4 Calculate the efficiency with which the 5° wedge elevates the weight W under the action of the horizontal force P on the wedge (Fig. 4). The coefficient of friction between the wedge and block is 0.30.

Q. No. 5 Rod *ABC* (Fig. 10) is attached to blocks *A* and *B* that can move freely in the guides shown. The constant of the spring attached at *A* is *k*=3 kN/m, and the spring is unstretched when the rod is vertical. For the loading shown, determine the value of θ corresponding to equilibrium.

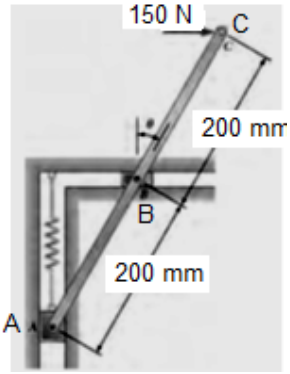


Fig. 5

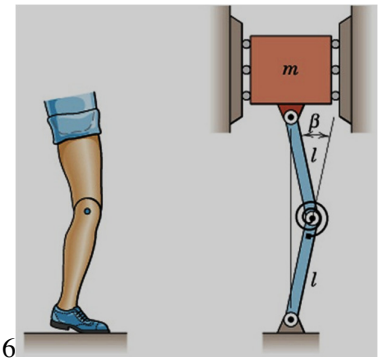


Fig. 6

Q. No. 6 One of the critical requirements in the design of an artificial leg for an amputee is to prevent the knee joint from buckling under load when the leg is straight. As a first approximation, simulate the artificial leg by the two light links with a torsion spring at their common joint (Fig. 6). The spring develops a torque $M=K\beta$, which is proportional to the angle of bend β at the joint. Determine the minimum value of K which will ensure stability of the knee joint for $\beta=0$.

Section 2: Tutorial Questions

Q. No. 7 Specify the horizontal force F necessary to maintain equilibrium of the 80-kg platform (Fig. 7) in terms of the angle θ made by the supporting links with the horizontal. Each of the three uniform links has a mass of 10 kg. (Compare the solution by virtual work with a solution by force and moment equilibrium.)

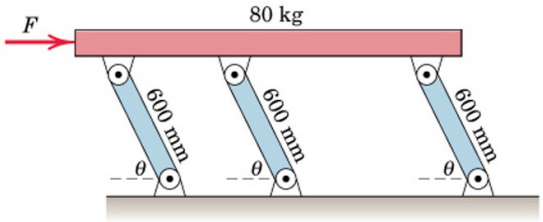


Fig. 7

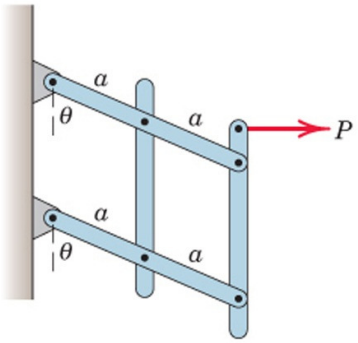


Fig. 8

Q. No. 8 Each of the four uniform links (Fig. 8) has a mass m. determine the horizontal force P required to hold them in place in the vertical plane as shown.

Q. No. 9 When u=0, the spring (Fig. 9) of stiffness k is uncompressed. As u increases, the rod slides through the pivoted collar at A and compresses the spring between the collar and the end of the rod. Determine the force P required to produce a given displacement u. Assume the absence of friction and neglect the mass of the rod.

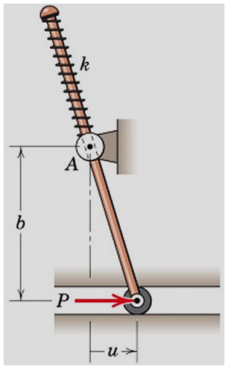


Fig. 9

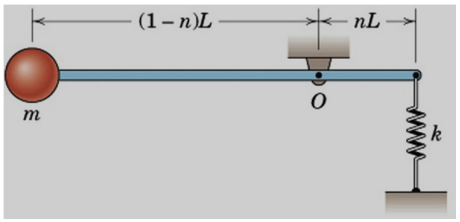


Fig. 10

Q. No. 10

The system of freely pivoted light bar (Fig. 5), end mass m, and spring of stiffness k is shown in its equilibrium configuration. The parameter n is a fraction which lies in the range $0<n<1$. Show that the system is stable for all values of n in the permitted range.