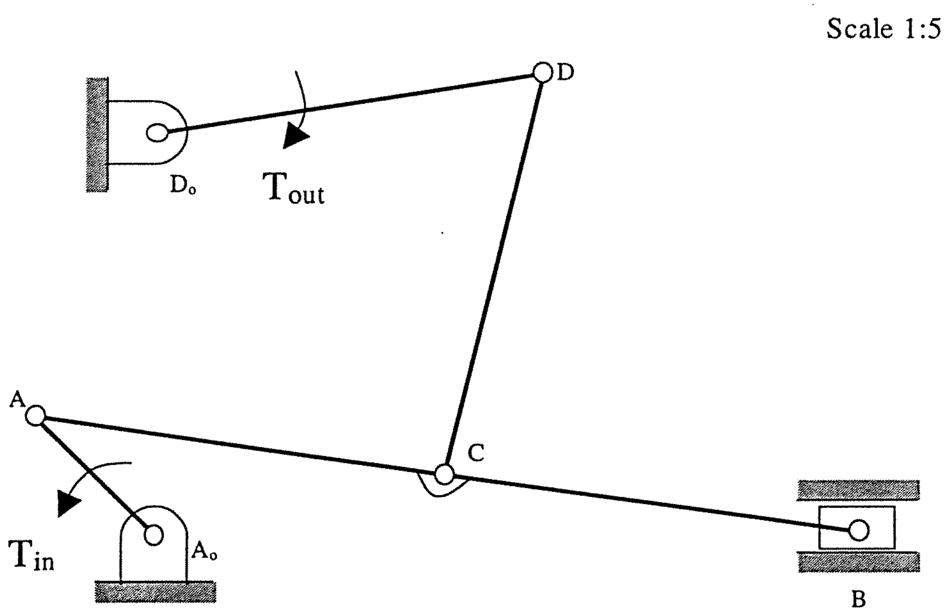
National Exams May 2003
98-Mec-A3, Kinematics and Dynamics of Machines
3 Hours Duration

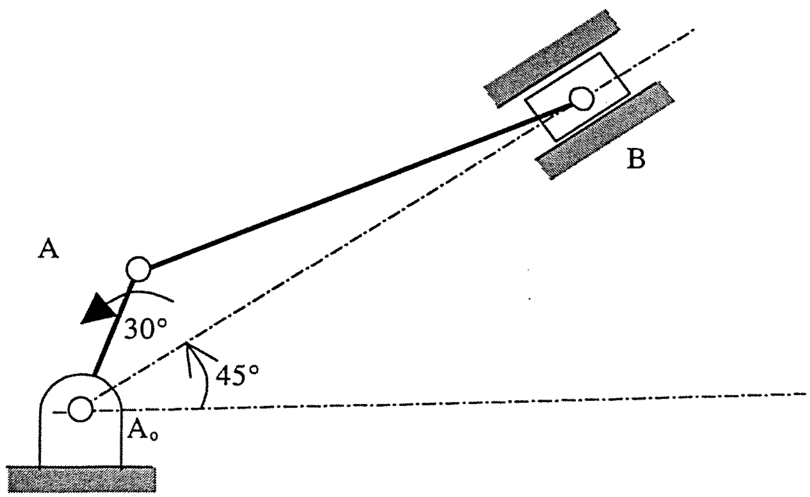
Notes
1. If in doubt as to the interpretation of any question, the candidate is urged to submit with the answer paper, a clear statement of any assumptions made.
2. This is an OPEN BOOK exam. Candidates may use one of the two calculators, the Casio or Sharp approved models.
3. Any five questions (20 marks for each question) constitute a complete paper. If you choose to answer more than five questions, only the first five questions as they appear in your answer book will be marked.

1. A planar mechanism shown below is driven by a torque applied to the input link A_oA. Determine (a) the degree(s) of freedom of the mechanism using Gruebler's formula, (b) the instant mechanical advantage defined as the ratio of the output torque to the input torque. In your calculation of the M.A., ignore friction and inertia forces everywhere. [Hint: complete the velocity analysis using the graphical method by assuming a unit angular velocity of the input link.]



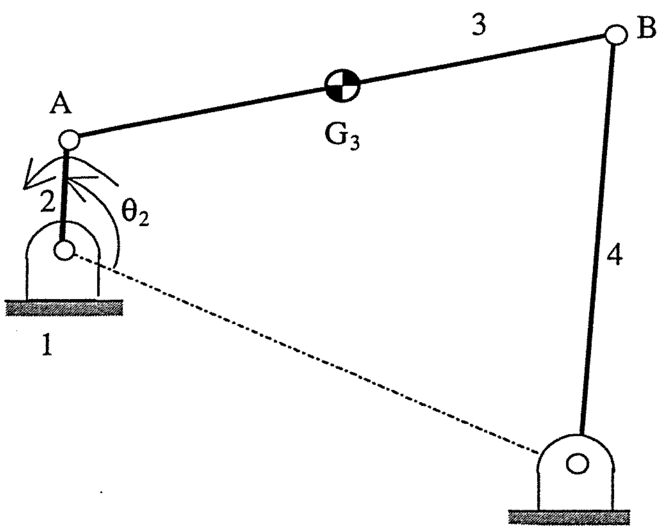
Use the space below to complete the velocity diagram.

2. A crank-slider mechanism is shown below. Determine (a) all instant centers, and (b) the velocity of the slider. The crank is rotating at 1000 rpm (ccw) at the moment shown. In your answer to (a), you must label properly each instant centre in the diagram.



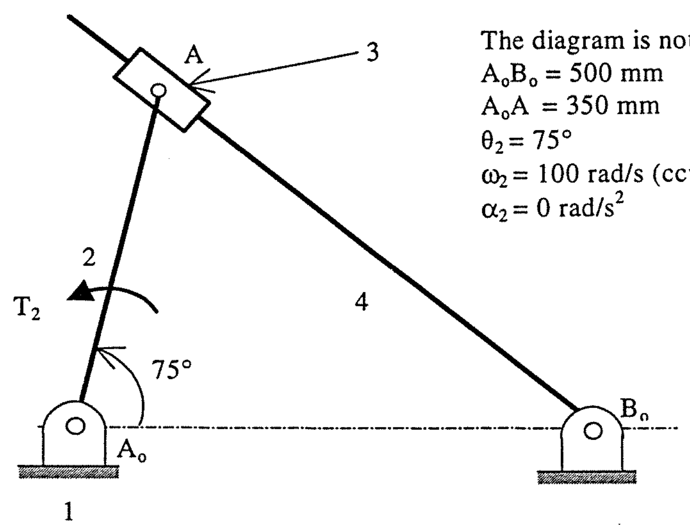
Not to scale
$A_oA = 2''$
$AB = 6''$

3. A four-bar planar mechanism is shown below. If link 2 is the input link, determine (a) the type of mechanism using the Grashof criteria, (b) the range of motion of the output link, (c) the range of variation of the transmission angle, and (d) the path of the mass centre of the coupler, located at the midpoint of AB.



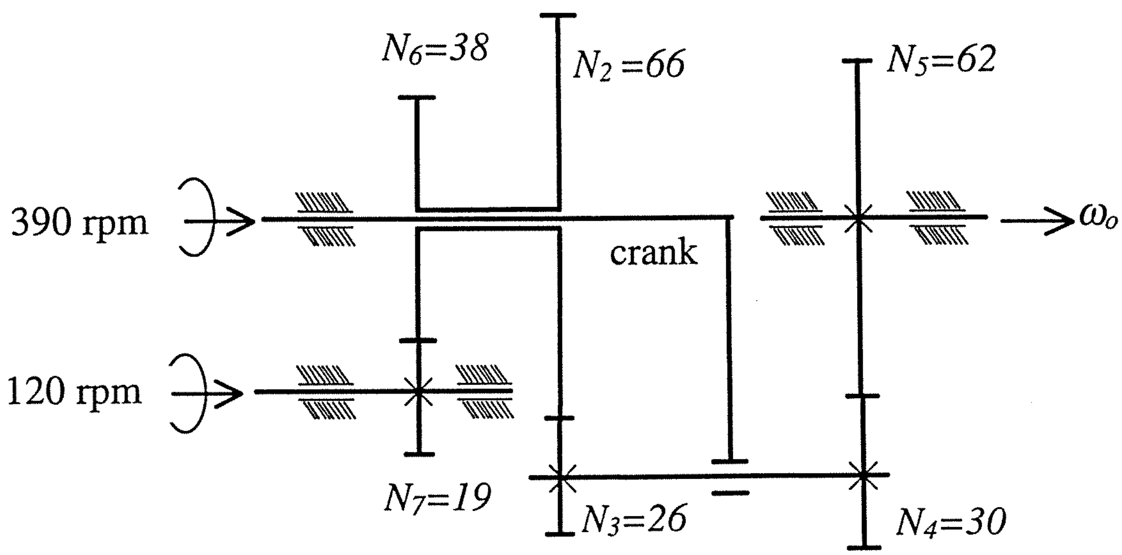
The diagram is not drawn to scale.
$r_1 = 6.8$ cm
$r_2 = 1.3$ cm
$r_3 = 6.7$ cm
$r_4 = 5.2$ cm

4. A four-bar inverted crank slider mechanism is shown below. The massless input link rotates at a constant angular velocity. The slider, which may be considered as a point mass in force analysis, has a mass of 2 kg. The mass moment of inertia of link AB_o about B_o is 0.3 kg•m^2. All pin joints and slide joints are smooth. Determine (a) the magnitude and direction of the Coriolis accelerations, $a^c_{A3/A4}$, (b) the angular acceleration of link AB_o, (c) the magnitude and direction of the dynamic force acting on link AB_o from the slider, and (d) dynamic force at joint A.

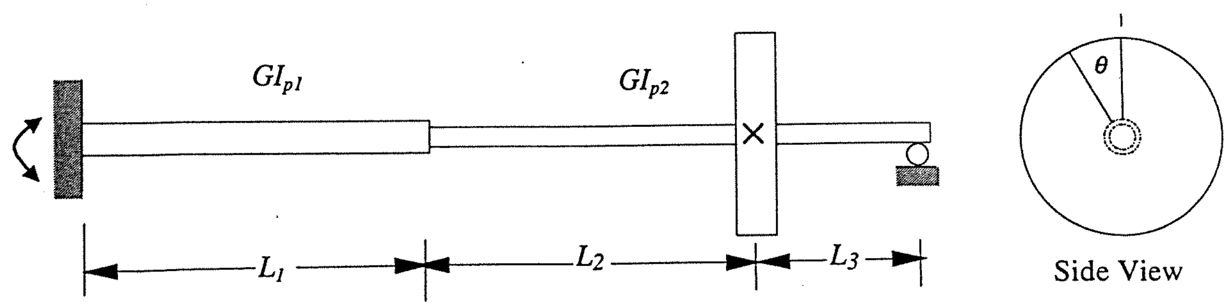


The diagram is not drawn to scale.
A_oB_o = 500 mm
A_oA = 350 mm
$\theta_2 = 75°$
ω_2 = 100 rad/s (ccw)
α_2 = 0 rad/s^2

5. A gear train system is shown below. If all gears have identical diametral pitch, determine the output angular velocity ω_o



6. A shafting system, consisting of two uniform steel segments (d_1 = 20 mm, L_1 = 200 mm; d_2 = 15 mm, L_2 = 150 mm; L_3 = 100 mm; G = 70 GPa) and a circular disk (J = 0.05 kg m^2), is shown below. If the mass of the stepped shaft is negligible, determine the period of free torsional vibration.



7. [20] A vibration system consisting of a massless beam, a block constrained to move in the horizontal direction, and a dashpot. For $EI = 2{,}300\ \text{Nm}^2$, $l = 2$ m, $m = 100$ kg, c = 120 Ns/m, determine (a) the response of the system due to the horizontal base motion $x_b = 5\sin 10t$ (mm), (b) the dynamic force acting on the block from the supporting beam, and the dynamic force transmitted to the dashpot support at D.