5.10. In a two-color printing press, two pairs of large printing drums are rotated from a single drive shaft as shown in Fig. 5.29. Each drum pair has total rotary inertia J, and is supported in bearings with a linear rotational drag coefficient B. The drive-shaft sections each have a torsional stiffness K. The system is driven by a motor that may be considered as an angular velocity source. Derive a set of state equations for this system.

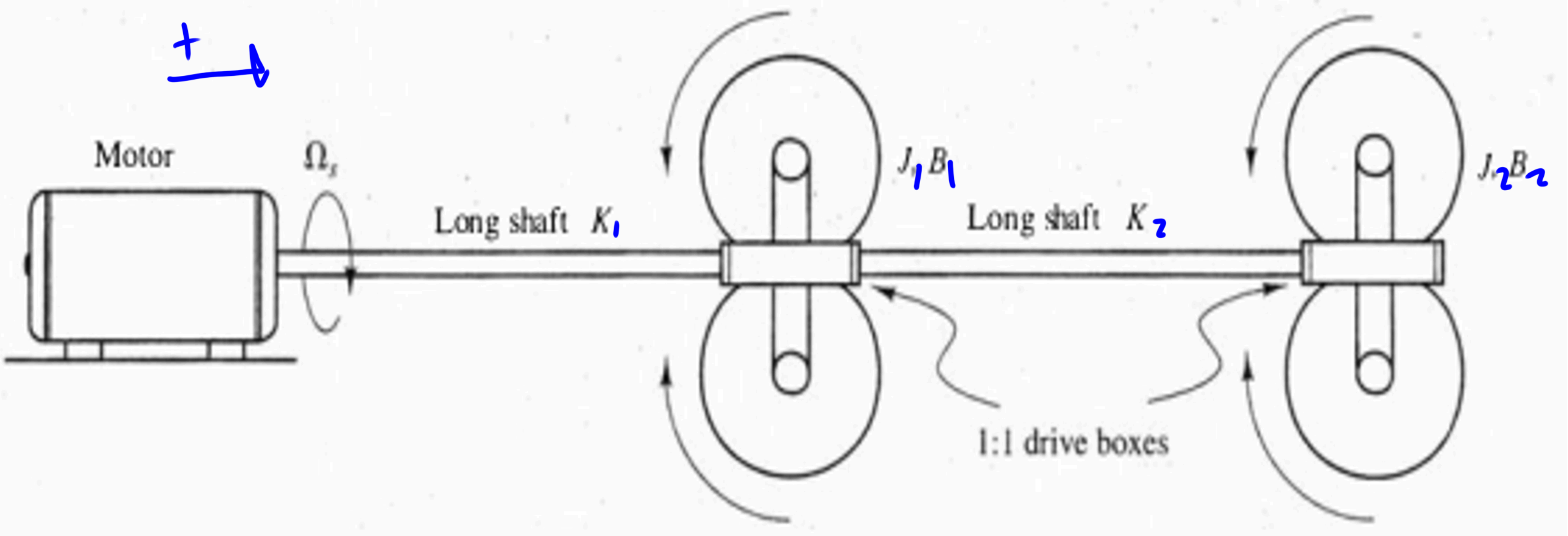
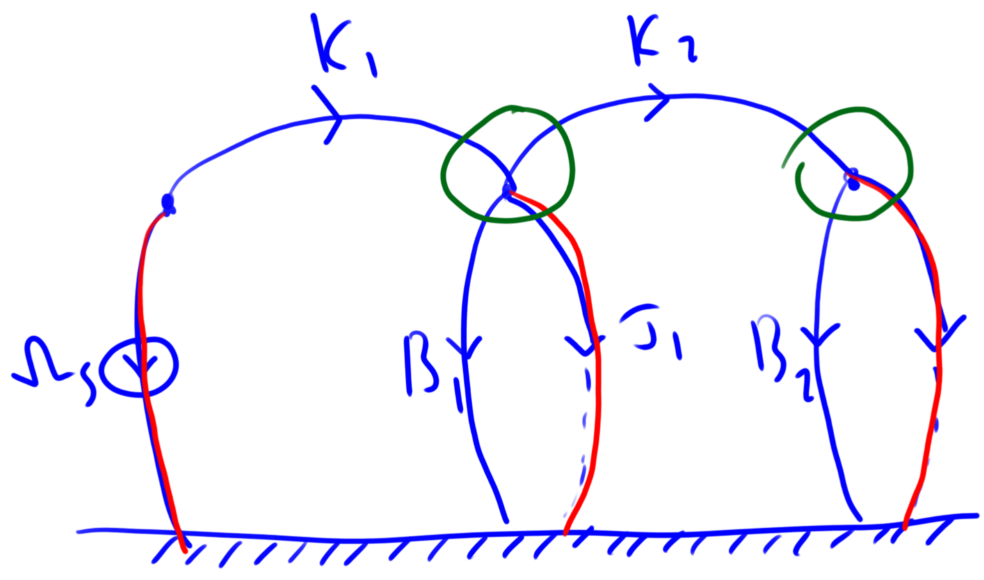


Figure 5.29: A rotary drive system.



primary: Ω_s ω_{J_1} ω_{J_2} τ_{K_1} τ_{K_2} τ_{B_1} τ_{B_2}

secondary: T_s τ_{J_1} τ_{J_2} ω_{K_1} ω_{K_2} ω_{B_1} ω_{B_2}

State: ω_{J_1} ω_{J_2} τ_{K_1} τ_{K_2}

elemental eq'ns

$$\frac{d\omega_{J_1}}{dt} = \frac{1}{J_1}\tau_{J_1}$$

$$\frac{d\omega_{J_2}}{dt} = \frac{1}{J_2}\tau_{J_2}$$

$$\frac{d\tau_{K_1}}{dt} = K_1\omega_{K_1}$$

$$\frac{d\tau_{K_2}}{dt} = K_2\omega_{K_2}$$

State Variable elemental eq'ns

$$\tau_{B_1} = B_1\omega_{B_1}$$
$$\tau_{B_2} = B_2\omega_{B_2}$$

other elemental eq'ns

continuity

$$\tau_{J_2} = \tau_{K_2} - \tau_{B_2}$$
$$\tau_{J_1} = \tau_{K_1} - \tau_{K_1} - \tau_{B_1}$$

Compatibility

$$\omega_{B_1} = \omega_{J_1}$$
$$\omega_{B_2} = \omega_{J_2}$$
$$\omega_{K_2} = \omega_{J_1} - \omega_{J_2}$$
$$\omega_{K_1} = \Omega_s - \omega_{J_1}$$

Constraint eq'ns