CONTROL SYSTEMS ENGINEERING D227
SOLUTION Q 11

COMMENT –Even the examiner admits that this question was a gift and its hard to believe that such an easy question is set alongside questions requiring vastly more effort.

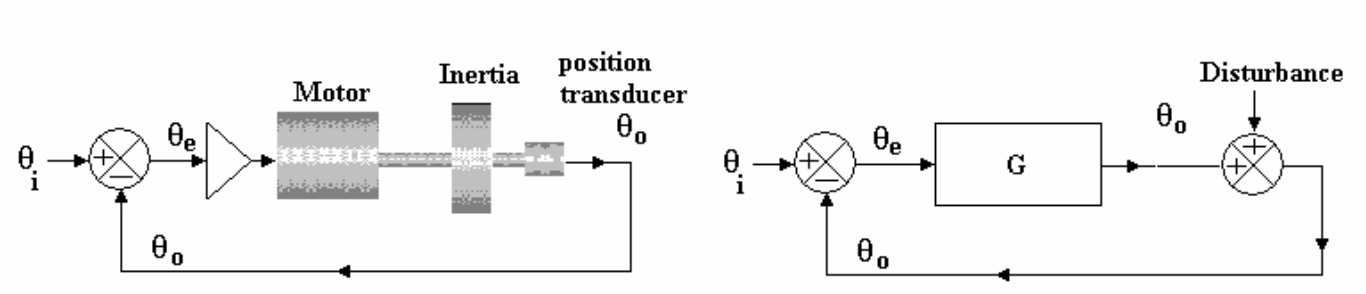
An electric motor rotates an inertia of 160 kg m2 with viscous damping of 640 Nm s/rad. The correcting action torque is 2880 Nm per radian of misalignment between the shaft and input reference position.

(a) Calculate the steady state misalignment of the mass when a disturbing torque of 1000 Nm is suddenly applied.

(b) State what additional control action you would include in the forward loop in order to eliminate misalignment due to step disturbances.

SOLUTION

The diagram visualises the system. %he disturbance is added to the output.



The torque output of the motor is 2880 θ_e.
The torque must overcome inertia and damping plus the disturbance D
$T = J\alpha + k\omega + D$

$$T = 2880\theta_e = J\frac{d^2\theta}{dt^2} + k\frac{d\theta}{dt} + D$$

$$2880(\theta_i - \theta_o) = 160\frac{d^2\theta_o}{dt^2} + 640\frac{d\theta_o}{dt} + D$$

$$2880\theta_i - 2880\theta_o = 160s^2\theta_o + 640s\theta_o + D$$

In the steady state s = 0 $2880\theta_e = D = 1000$ so $\theta_e = 1000/2880 =$ **0.347 rad Answer (a)**

The disturbance produces an offset error. This may be eliminated by introducing integral action in the controller to increase the value of θ_e until the offset is removed.