Physics

1. (a) Three equations of angular motion are:

   $\omega = \omega_0 + \alpha t$ (relates final angular velocity, initial angular velocity, angular acceleration, and time)

   $\theta = \theta_0 + \omega_0 t + \frac{1}{2}\alpha t^2$ (relates angular displacement, initial angular velocity, angular acceleration, and time)

   $\omega^2 = \omega_0^2 + 2\alpha(\theta - \theta_0)$ (relates final and initial angular velocities, angular acceleration, and angular displacement)

1. (b) Angular Acceleration and Linear Acceleration:

Given: Revolutions per 20 seconds

Convert revolutions per 20 seconds to angular velocity:

$\text{Angular velocity } (\omega) = \frac{2\pi \text{ rad}}{20 \text{ sec}} = \frac{\pi}{10} \text{ rad/s}$

Calculate Angular Acceleration (α):

$\alpha = \frac{\Delta\omega}{\Delta t} = 0 -$
$\frac{\pi}{10} \text{ rad/s (initial angular velocity is assumed to be 0) } /20\,\text{s} = -\frac{\pi}{200} \text{ rad/s}^2$

Given radius $r = 350\,\text{mm} = 0.35\,\text{m}$

Linear Acceleration (a) at the rim:

$a = r \times \alpha = 0.35\,\text{m} \times -\frac{\pi}{200} \text{ rad/s}^2 = -0.00175\,\text{m/s}^2$

2. (a) Formula for calculating coefficient of linear expansion (α):

   $\alpha = \frac{\Delta L}{L \cdot \Delta T}$, where ΔL is the change in length, L is the original length, and ΔT is the change in temperature. Its SI unit is per degree Celsius (°C) or per Kelvin (K).

2. (b) Change in Length of Copper Bar:

Given: Coefficient of linear expansion for copper ($\alpha = 1.7 \times 10^{-5}/^\circ C$)

Assuming the initial temperature of the copper bar is 20°C:
Change in temperature (ΔT) = 110°F - 20°C = 110°F - 68°F = 42°C

Using the formula $\Delta L = L \cdot \alpha \cdot \Delta T$:

$$\Delta L = 50\,\mathrm{m} \times 1.7 \times 10^{-5}/^\circ C \times 42^\circ C = 0.0357\,\mathrm{m} = 35.7\,\mathrm{mm}$$

3. (a) (i) Hook's Law states that the force needed to extend or compress a spring by some distance is proportional to that distance.
   (ii) Elastic properties refer to the ability of a material to regain its original shape after deformation, while plasticity refers to a material's ability to permanently deform without breaking when a force is applied.

3. (b) Extension of Mild Steel Rod:

Given: Length ($L = 4\,\mathrm{m}$), diameter ($d = 30\,\mathrm{mm} = 0.03\,\mathrm{m}$), force ($F = 100\,\mathrm{kN} = 100000\,\mathrm{N}$), Young's modulus ($E = 200\,\mathrm{GPa} = 200 \times 10^9\,\mathrm{Pa}$)

Calculate Cross-sectional Area (A):

$$A = \pi \times \left(\frac{d}{2}\right)^2 = \pi \times \left(\frac{0.03\,\mathrm{m}}{2}\right)^2 = 7.065 \times 10^{-4}\,\mathrm{m}^2$$

Now, use the formula $\Delta L = \frac{FL}{AE}$:

$$\Delta L = \frac{100000\,\mathrm{N} \times 4\,\mathrm{m}}{200 \times 10^9\,\mathrm{Pa} \times 7.065 \times 10^{-4}\,\mathrm{m}^2} = 0.283 \times 10^{-3}\,\mathrm{m} = 0.283\,\mathrm{mm}$$

Summary of Answers:

1. (b) Angular acceleration = $-\frac{\pi}{200}\,\mathrm{rad/s}^2$, Linear acceleration = $-0.00175\,\mathrm{m/s}^2$
2. (b) Change in length of copper bar = $35.7\,\mathrm{mm}$
3. (b) Extension of mild steel rod = $0.283\,\mathrm{mm}$