2 Rotational Motion and Friction

2.1 (a) Calculate the maximum static frictional force that can act on the block.

The normal force $N = mg = 2.5 \text{ kg} \times 9.81 \text{ m/s}^2 = 24.525 \text{ N}$. The maximum static frictional force $f_{s,max}$ is:

$$f_{s,max} = \mu_s N = 0.4 \times 24.525 \text{ N} = 9.81 \text{ N}$$

2.2 (b) Determine whether the block will slide or stay in place.

The required centripetal force is $F_c = m\omega^2 r$:

$$F_c = 2.5 \text{ kg} \times (3 \text{ rad/s})^2 \times 0.3 \text{ m} = 6.75 \text{ N}$$

Since $F_c = 6.75 \text{ N} < f_{s,max} = 9.81 \text{ N}$, the block will **stay in place**.

2.3 (c) Calculate the minimum coefficient of friction required for the block to stay in place at the edge.

At the edge, $r_{\text{edge}} = 0.5 \text{ m}$. The required centripetal force is:

$$F_{c,\text{edge}} = m\omega^2 r_{\text{edge}} = 2.5 \times (3)^2 \times 0.5 = 11.25 \text{ N}$$

For the block to stay, $f_{s,max,min} = \mu_{s,min} mg \geq F_{c,edge}$.

$$\mu_{s,min} \geq \frac{11.25 \text{ N}}{2.5 \text{ kg} \times 9.81 \text{ m/s}^2} \approx 0.4587$$

The minimum coefficient is approximately **0.459**.

2.4 (d) Determine the speed of the block when it begins to slip.

Slipping begins when $\frac{mv^2}{r} = f_{s,max} = \mu_s mg$.

$$v = \sqrt{\mu_s g r} = \sqrt{0.4 \times 9.81 \times 0.5} = \sqrt{1.962} \approx 1.40 \text{ m/s}$$