



(a) $P = 0$

$$\sum F_y = 0: N - 491 \cos 15^\circ = 0, N = 474 \text{ N}$$

Assume equilibrium:

$$\sum F_x = 0: F - 491 \sin 15^\circ = 0, F = 127.0 \text{ N}$$

$$F_{\max} = \mu_s N = 0.25(474) = 118.4 \text{ N} < F;$$

assumption invalid and

$$F = F_k = \mu_k N = 0.2(474) = \underline{94.8 \text{ N}} \text{ up the incline}$$

(b) $P = 200 \text{ N}$; assume equilibrium

$$\sum F_y = 0: N - 491 \cos 15^\circ + 200 \sin 20^\circ = 0, N = 405 \text{ N}$$

$$\sum F_x = 0: 200 \cos 20^\circ - 491 \sin 15^\circ - F = 0, \underline{F = 61.0 \text{ N}}$$

$$F_{\max} = \mu_s N = 0.25(405) = 101.3 \text{ N} > 61.0 \text{ N} \text{ so assumption OK}$$

(c) $P = 250 \text{ N}$; assume equilibrium

$$\sum F_y = 0: N - 491 \cos 15^\circ + 250 \sin 20^\circ = 0, N = 388 \text{ N}$$

$$\sum F_x = 0: 250 \cos 20^\circ - 491 \sin 15^\circ - F = 0, F = 108.0 \text{ N}$$

$$F_{\max} = \mu_s N = 0.25(388) = 97.1 \text{ N} < F; \text{ assumption invalid}$$

$$F = \mu_k N = 0.2(388) = \underline{77.7 \text{ N}} \text{ down the incline}$$

(d) To initiate motion, set $F = \mu_s N = 0.25 N$ down the incline:

$$\sum F_y = 0: N - 491 \cos 15^\circ + P \sin 20^\circ = 0$$

$$\sum F_x = 0: P \cos 20^\circ - 491 \sin 15^\circ - 0.25 N = 0$$

$$\text{Solve to obtain } \begin{cases} N = 392 \text{ N} \\ \underline{P = 239 \text{ N}} \end{cases}$$