8. (20 pts) A large steam locomotive has a mass of $2 \times 10^5$ kg (about 220 tons). The coefficient of friction of steel on steel is .6 ($\mu = .6$).

(a) (3 pts) When on level track, how hard can the locomotive pull before the wheels start to slip?

Maximum pulling force $= \mu m g = 1.18 \times 10^6$ Newtons

$$\mu m g = (.6) (2 \times 10^5)(9.8)$$

(b) (3 pts) Suppose the locomotive is going up a steep $26^\circ$ grade. What is the magnitude of $\pm F_n$, the normal force that the engine exerts on the track and the track exerts back on the engine?

$$\| F_n \| = m g \cos \theta = 1.76 \times 10^6$$ Newtons

$$m g \cos \theta = (2 \times 10^5)(9.8) \cos 26^\circ$$