4.11

Constant force $\Rightarrow$ impulse $I = \int_0^t F\,dt = Ft$

Steady rate $\Rightarrow$ $m = bt$

Momentum at $t = 0$: $P(0) = 0$

" " t : $P(t) = (M+m)V$

We have

$$I = P(t) - P(0)$$

$$\Rightarrow V = \frac{Ft}{M+m} = \frac{Fm}{(M+m)b}$$

Problem 3

W-E theorem

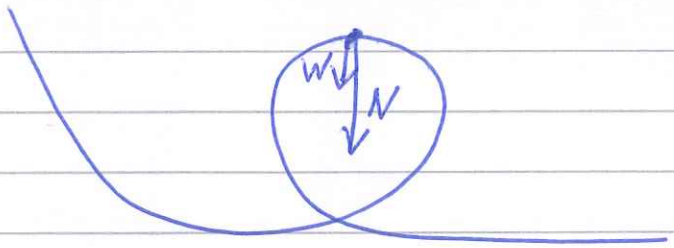
$$K_a - K_o = W_{ao}$$

$$K_o = 0 \qquad K_a = \frac{1}{2} m V_a^2$$

W_{ao} = mg × height difference

$$= mg\,(z - 2R)$$

Force diagram at a:



Circular motion

$$\Rightarrow W + N = \frac{m V_a^2}{R} = m R \dot{\theta}^2$$

$$mg + N = \frac{m V_a^2}{R} \qquad (*)$$

We want $N = n\,mg$

$$\Rightarrow (n+1)mg = \frac{m V_a^2}{R} \qquad (**)$$

The W-E theorem gives

$$\frac{1}{2} m V_a^2 = mg\,(z - 2R)$$

$$\Longrightarrow \quad V_a^2 = 2mg(z-2R)$$

Substitution in (**) gives

$$(n+1)g = \frac{2g}{R}(z-2R)$$

$$\Longrightarrow \quad z-2R = R(n+1)\frac{1}{2}$$

$$z = \frac{R}{2}(n+5)$$