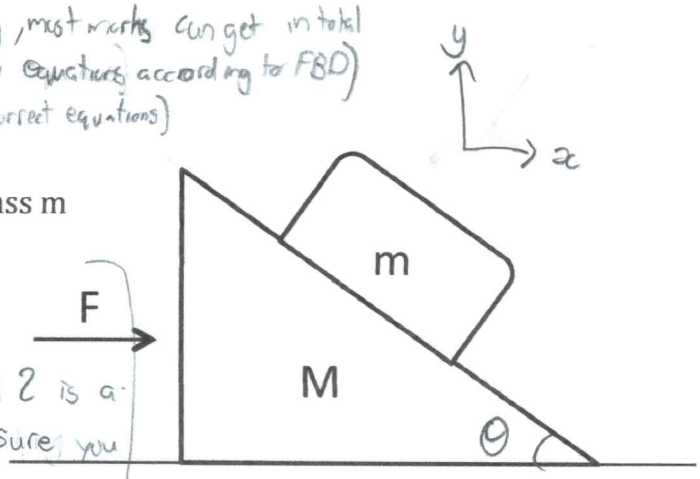
Correct FBDs : 3 marks
" Equations : 2 marks
Final Answer : 3 marks

If FBD is wrong, most marks can get in total is 2 (correct eq. according to FBD) or 1 (not correct equations)

**Question 4**

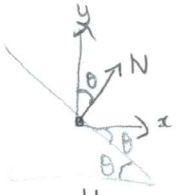
Find the minimum force (F) needed to keep mass m from sliding on top of incline M.
No friction. [8]



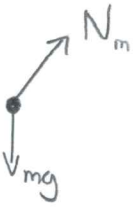

Method 1 makes more sense by just analyzing the forces. It's the method that "always works." Method 2 is a "shortcut." Be careful with using shortcuts by making sure you are allowed to use them in the question.

→ Method 1 : No system analysis.

(m)




$N_x = N\sin\theta$
$N_y = N\cos\theta$

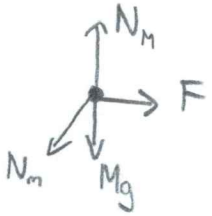



$F_{net_x} = ma_x = N_m \sin\theta$ ①

$F_{net_y} = 0 = N_m\cos\theta - mg$

$\Rightarrow N_m = \frac{mg}{\cos\theta}$ ②

(M)




$F_{net_x} = Ma_x = F - N_m\sin\theta$ ③

$F_{net_y} = 0 = N_M - Mg - N_m\cos\theta$ ④

By inspection, ④ is useless.

Sub ② into ① $\Rightarrow ma_x = \left(\frac{mg}{\cos\theta}\right)\sin\theta \Rightarrow a_x = g\tan\theta$ ⑤

Sub ⑤ into ③ and ② also into ③.

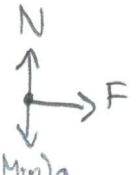
$\Rightarrow M(g\tan\theta) = F - \left(\frac{mg}{\cos\theta}\right)\sin\theta = F - mg\tan\theta$

$\Rightarrow F = Mg\tan\theta + mg\tan\theta = (M+m)g\tan\theta$

$F = (M+m)g\tan\theta$

→ Method 2 : System analysis.

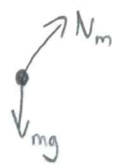
(M+m)




$F_{net_y} = 0 = N - (M+m)g \Rightarrow N = (M+m)g$

$F_{net_x} = (M+m)a_x = F$ ③

(m)




Use same equations from method 1.

$ma_x = N_m\sin\theta$ ①

$N_m = \frac{mg}{\cos\theta}$ ②

Sub ② into ① $\Rightarrow a_x = g\tan\theta$ ④

Sub ④ into ③.

$(M+m)(g\tan\theta) = F$

$F = (M+m)g\tan\theta$