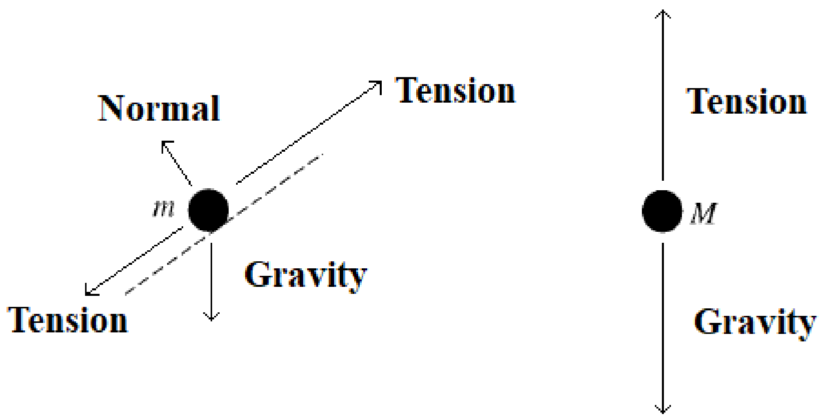
2019 AP Physics C Mechanics Free Response, Version 2

1a.



1b.i.

The net force on the two-block system is zero, so $0 = T_2 - 3mg \cdot \sin\theta$.

$T_2 = 3mg \cdot \sin\theta$

1b.ii.

The net force on the system along the line of motion is zero, so $0 = Mg - 3mg \cdot \sin\theta$.

$M = 3m \cdot \sin\theta$

1c.i. T_1 decreases to zero

1c.ii. The velocity of the block is up the ramp.

1c.iii. The acceleration of the block is down the ramp.

1d. At the minimum mass of M, the net force along the line of motion is zero so that the forces up the incline are equal in magnitude to the forces down the incline.

$Mg + \mu_s 3mg \cdot \cos\theta = 3mg \cdot \sin\theta$

$M = 3m(\sin\theta - \mu_s \cos\theta)$

1e. $\sum F = ma$ on the three-block system, so $3mg \cdot \sin\theta - \mu_k 3mg \cdot \cos\theta = ma$ and $a = g(\sin\theta - \mu_k \cos\theta)$

$v_f = \sqrt{2ad} = \sqrt{2gd(\sin\theta - \mu_k \cos\theta)}$

2a. F = 4.5 – 0.125t^2 so J = $\int 4.5 - 0.125t^2 \cdot dt$ = 4.5t - $\frac{0.125}{3}t^3$

With boundaries of 0s and 6s, J = 18N·s

2b. 18N·s = Δp = (0.5kg)(Δv), so Δv = 36m/s.

2c.i. K = ½(0.5)(36^2) = 324J

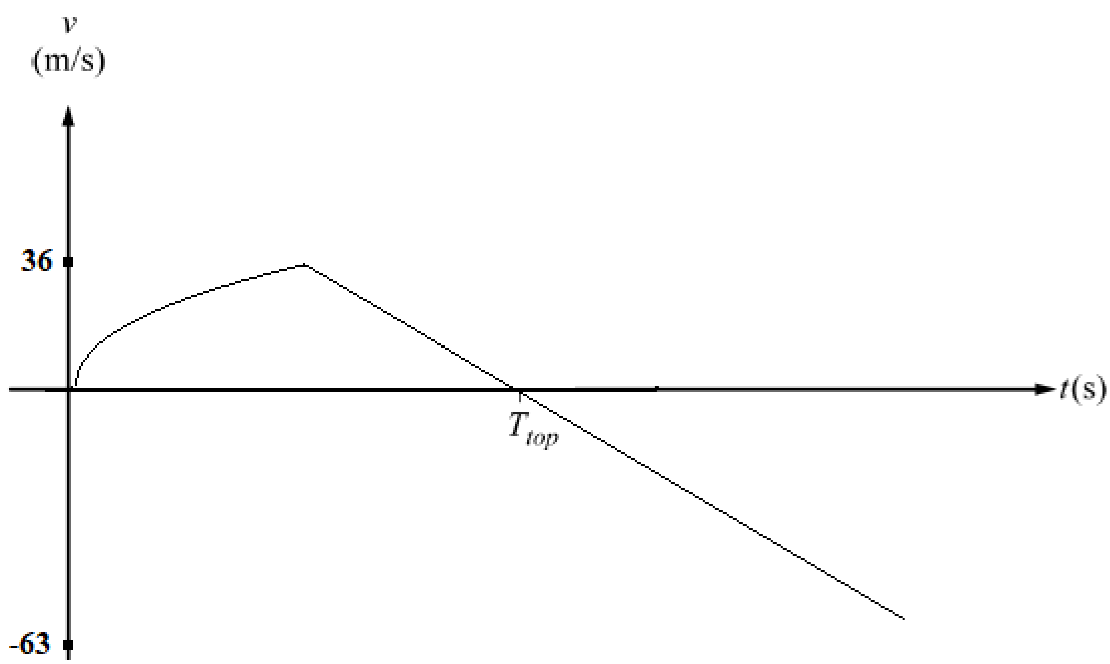
2c.ii. y = $\int 9t - \frac{0.25}{3}t^3 \cdot dt$ = 4.5t^2 - $\frac{0.25}{12}t^4$ with bounds of 0s and 6s is 135m.

U = (0.5)(10)(135) = 675J

2d. At a height of 135m, the velocity is 36m/s. The further displacement is $\frac{36^2}{(2)(10)}$ = 65m

The maximum height reached is then 200m.

2e.



3a. At the top of the loop, $\sum F = \frac{-mv^2}{R}$ = -mg.

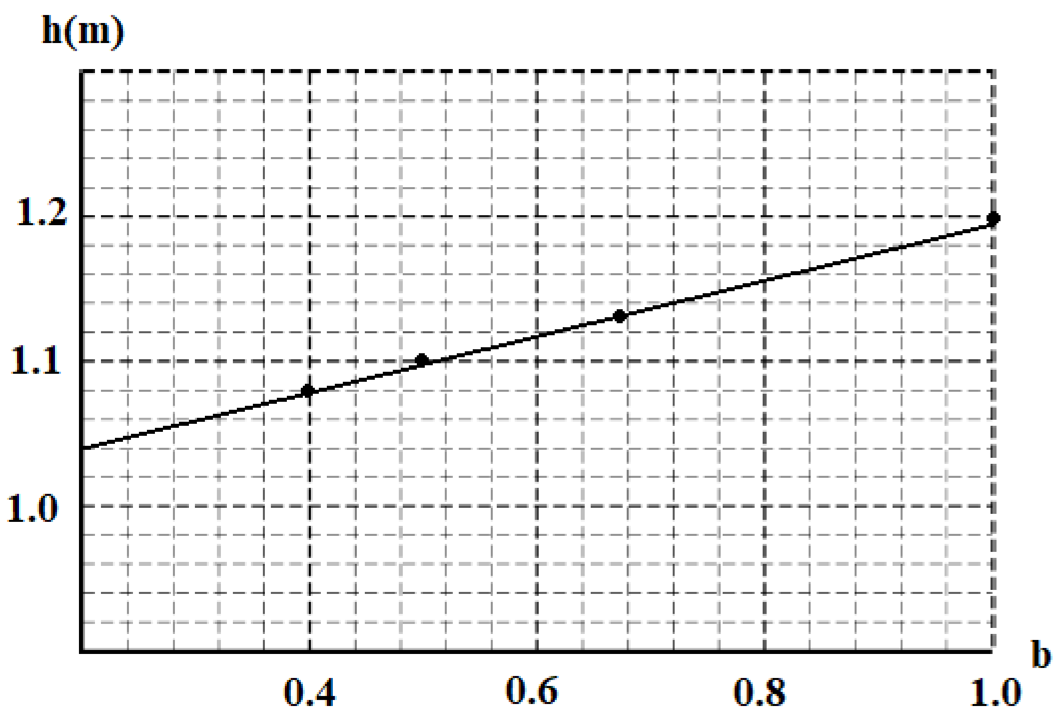
$v_{min} = \sqrt{Rg}$

3b. By conservation of energy, $U_G = U_G + K_{linear} + K_{rotation}$

$mgh = mg(2R) + ½·m·Rg + ½·(bmr^2)(\frac{Rg}{r^2})$

$h = R(\frac{5}{2} + \frac{b}{2})$

3c.



3d. At a height of 1.16m, the value for b is approximately 0.8.

3e. $1.16 = R(\frac{5}{2} + \frac{0.8}{2})$

R = 0.4m

3f. Less. The sphere's center of mass at the top of the loop would be significantly lower than 2R, so the gravitational potential energy would be less at that point also. Lesser potential energy at the top of the loop requires lesser initial potential energy for the same minimum kinetic energy at the top.