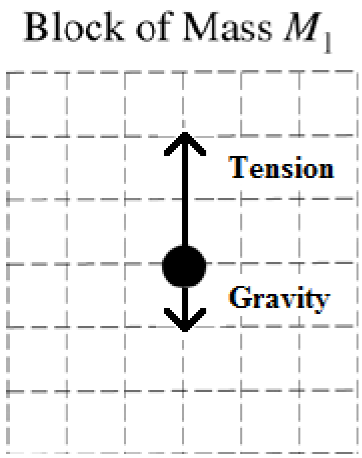
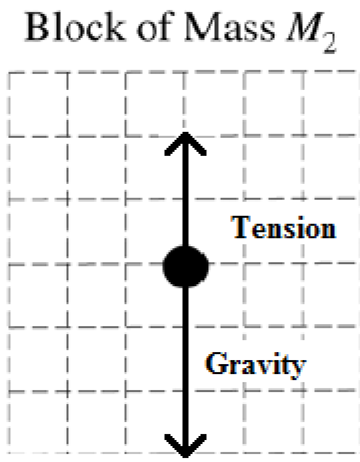
# 2017 AP Physics C Mechanics Free Response Answers

1.a.




1b.

$-M_1 \cdot g + F_T = M_1 \cdot a$

$M_2 \cdot g - F_T = M_2 \cdot a$

$F_T = M_1 \cdot a + M_1 \cdot g = M_2 \cdot g - M_2 \cdot a$

$M_1 \cdot a + M_2 \cdot a = M_2 \cdot g - M_1 \cdot g$

$a = \frac{M_2 - M_1}{M_1 + M_2} g$

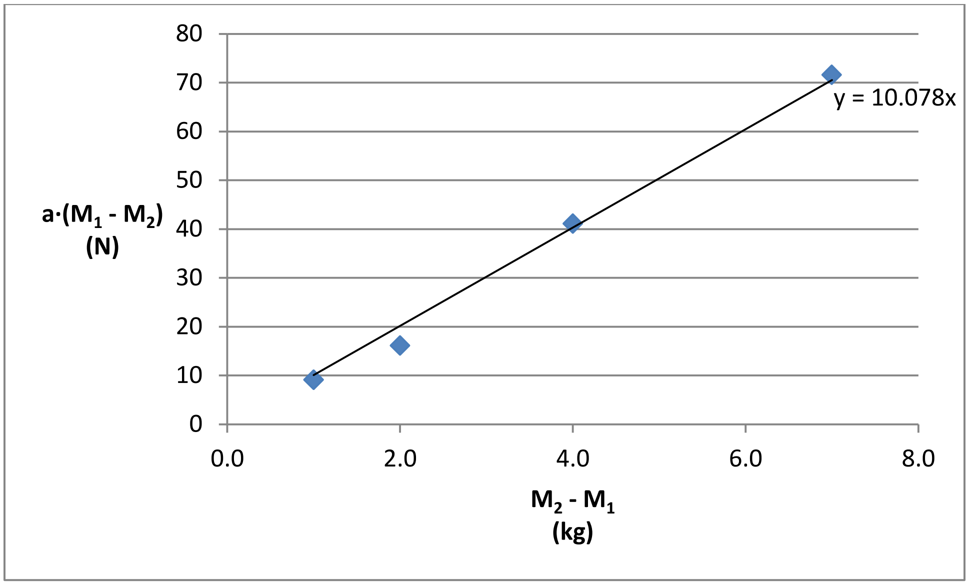
1c.

Vertical: $a \cdot (M_1 + M_2)$

Horizontal: $M_2 - M_1$

| | | | | | |
|---|---|---|---|---|---|
| $M_1$ (kg) | 1.0 | 2.0 | 5.0 | 6.0 | 10.0 |
| $M_2$ (kg) | 2.0 | 3.0 | 12.0 | 8.0 | 14.0 |
| a ($m/s^2$) | 3.02 | 1.82 | 4.21 | 1.15 | 1.71 |
| | | | | | |
| $a \cdot (M_1 + M_2)$ | 9.06 | 9.1 | 71.57 | 16.1 | 41.04 |
| $M_2 - M_1$ | 1.0 | 1.0 | 7.0 | 2.0 | 4.0 |

1d.




1e.

g = 10.1 m/s$^2$

1f. The tension is greater in the first experiment.

In the second experiment, the tension is only responsible for causing block one to accelerate rightwards. This acceleration cannot be greater than g, so the tension cannot be greater than $M_1 \cdot g$.

In the first experiment, the tension in the cord must not only counteract the force of gravity on block one ($M_1 \cdot g$), but also cause block one to accelerate upwards. The tension must be greater than $M_1 \cdot g$.

1g. If there is kinetic friction between block one and the table, the acceleration of the block across the table will be less than on a frictionless surface. In a given trial, this lesser acceleration could reasonably be interpreted as resulting from a lower gravitational field or gravitational acceleration, g.

2a.i.

mgh = $\frac{1}{2}$mv$^2$

v = $\sqrt{2gh}$

2.a.ii.

Greater than. The acceleration down the incline is constant, so the greater the time of the acceleration, the greater the change in velocity. In the first half of the descent distance, the block is moving relatively slowly, so it will spend more time accelerating and have a greater increase in velocity. In the second half of the descent distance, the block is moving relatively quickly, so it will spend less time accelerating and have a lesser change in velocity. If the block speeds-up more in the first have of descent distance than in the second half, it must be traveling faster than half the maximum at the midpoint.

2b.

mgh = $\frac{1}{2}$kx$^2$

x = $\sqrt{\frac{2mgh}{k}}$

2c. T = 2π$\sqrt{\frac{m}{k}}$ and Δt = $\frac{T}{4}$ so Δt = $\frac{\pi}{2}\sqrt{\frac{m}{k}}$

2d.i.

ma = -βv$^2$

m·$\frac{dv}{dt}$ = -βv$^2$

$\frac{dv}{dt}$ = - $\frac{\beta}{m}$ v$^2$ or $\frac{dv}{dt} - \frac{\beta}{m}$ v$^2$ = 0

2.d.ii.

$\frac{dv}{dt} - \frac{\beta}{m}$ v$^2$ = 0

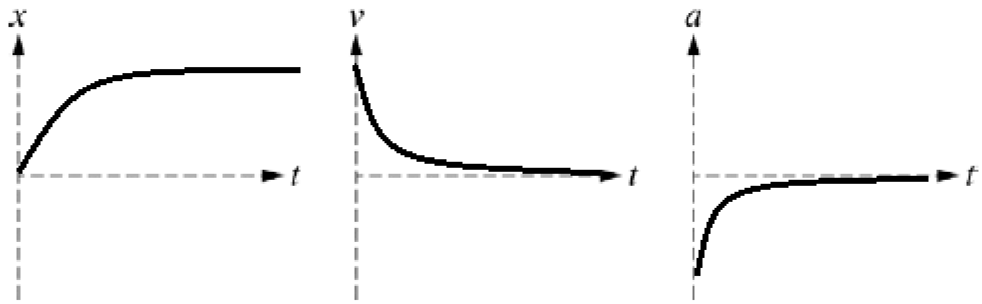
$\frac{1}{v^2}$ dv = $-\frac{\beta}{m}$ dt

$\left[\frac{-1}{v}\right] = -\frac{\beta}{m}$ t

$\frac{1}{v_0} - \frac{1}{v} = -\frac{\beta}{m}$ t

$\frac{1}{v} = \frac{1}{v_0} + \frac{\beta}{m}$ t

2e.



3a.

$K = U_i = mgh = (0.5)(9.8)(1.0 \cdot \sin 30°) = 2.45J$

3b.

$K = K_{rot} + K_{linear} = \frac{1}{2}\left(\frac{MR^2}{2}\right) \cdot \omega^2 + \frac{1}{2}M \cdot (\omega \cdot R)^2 = \frac{3}{4} \cdot MR^2 \cdot \omega^2$

$2.45 = \frac{3}{4} \cdot (0.50 \cdot 0.10^2) \cdot \omega^2$

$\omega = 25.56$ rad/s

3c.

$K_{rot} = \frac{1}{2}\left(\frac{MR^2}{2}\right) \cdot \omega^2 = \frac{1}{4}(0.5)(0.10^2)(25.56^2) = 0.8166J$

$E_{total} = K_{final} = Mgh = (0.5)(9.8)(0.75 + 1.0\sin 30°) = 6.125J$

$\frac{0.8166}{6.125} = 0.133$

3d.

$v = \omega \cdot R = 2.556m/s$

$\Delta t = \sqrt{\frac{2h}{g}} = 0.39s$

$D = (2.556)(0.39) = 1.0m$

3e.i.

Equal to. Both objects begin with the same gravitational potential energy. Energy is conserved for the total descent. Both end with that same energy when they land.

3e.ii.

Less than. A lower rotational inertia implies a lower resistance to rotational motion. The sphere will rotate down the ramp at a faster rate, leaving the table with a higher linear velocity. If the linear velocity is higher for the sphere (with both objects having the same total energy as they leave the table), the sphere will have a higher linear kinetic energy and therefore a lesser rotational kinetic energy.

3e.iii.

Greater than. For the reason described above, the sphere will leave the table with a higher linear velocity. The time of descent is the same for the sphere and cylinder; therefore, the sphere will travel a greater horizontal distance in that time.