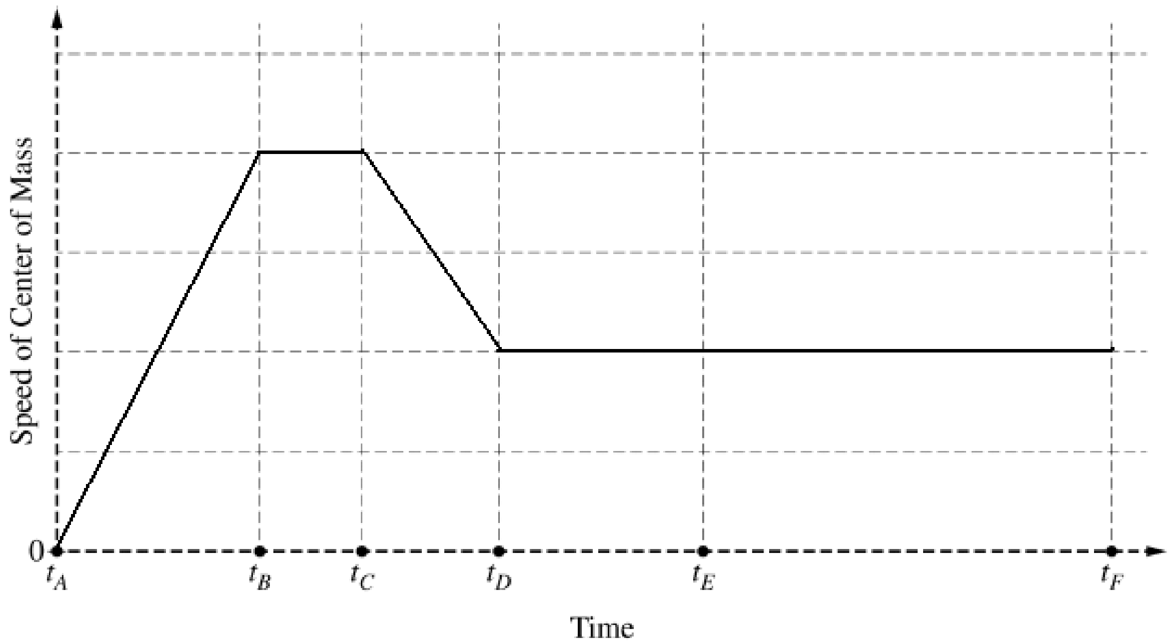
<u>2019 AP Physics 1 Free Response Answers</u>

1a.

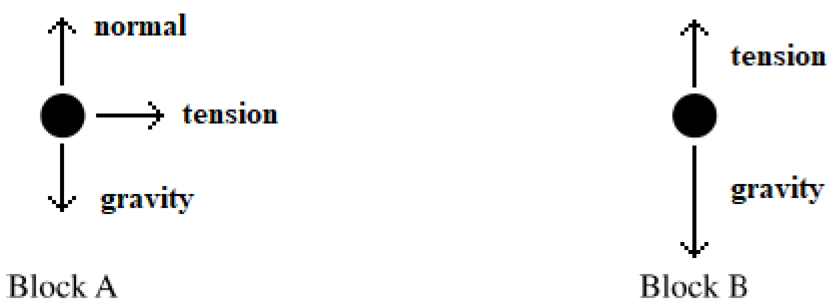


1b. From C to D only. Throughout the entire motion, the plunger, the normal force, and the force of gravity all apply a force through the center of mass. Therefore, as none of these forces apply a torque, they cause no change in angular momentum. From C to D, the force of friction does apply a clockwise torque which causes a clockwise change in angular momentum.

2a.i. The acceleration will be nearly zero. The inertia of block A is so large in comparison to the force of gravity on block B that the resultant acceleration will be negligible.

2a.ii. The acceleration will be nearly *g*. The inertia of block A is so small in comparison to the force of gravity on block B that block B will be nearly in freefall, resulting in the acceleration due to gravity.

2b.



2c.

$\sum F_{\text{on the system}} = m_{\text{system}} \cdot a$

$m_B \cdot g = (m_A + m_B) \cdot a$

$a = \frac{m_B \cdot g}{m_A + m_B}$

2d. Yes. If mass A is much less than mass B, then m_A can be considered as approaching zero. As m_A approaches zero, the acceleration of the system approaches *g*.

2e. $T_2 > T_1$. A pulley with non-negligible mass contributes resistance to the acceleration of the system. If this resistance increases, then the acceleration of the system decreases. A decreasing acceleration requires that the upwards force of tension on block B approaches the downward force of gravity, decreasing the net force and thus decreasing the acceleration.

3a.i. Conservation of energy.

3a.ii. $\frac{1}{2}kd^2 = \frac{1}{2}mv^2$ as the launcher fires the sphere horizontally off a tabletop edge

$t = \sqrt{\frac{2h}{g}}$ as the sphere falls from the tabletop height to the floor

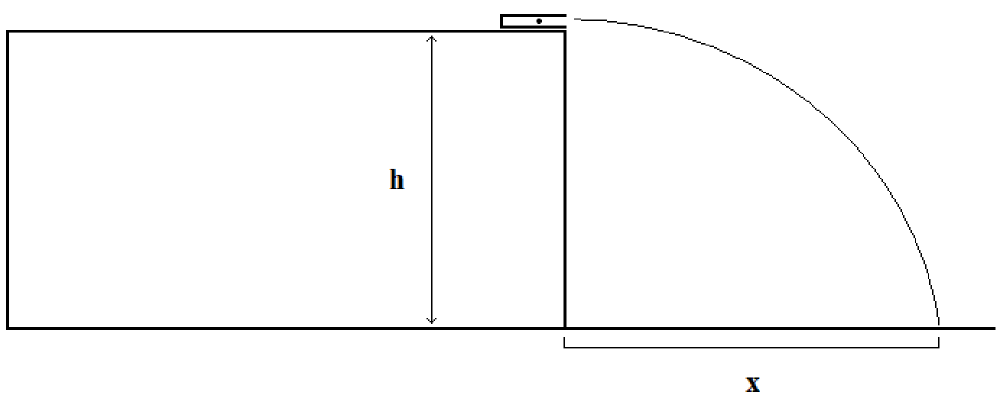
$x = v \cdot t$ as the projectile flies through the air

Therefore, $k = \frac{mx^2g}{2hd^2}$

3b.

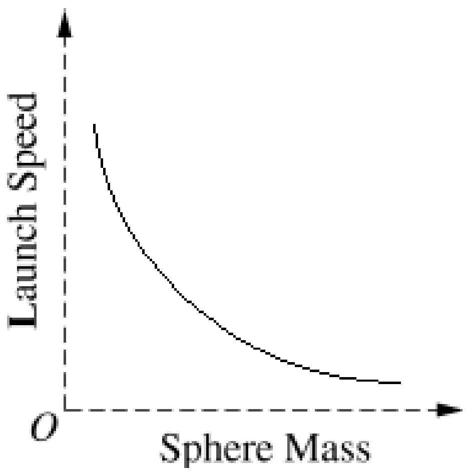
Quantity to be measured	Symbol for quantity	Equipment for measurement
Sphere mass	m	Pan balance
Spring compression	d	Ruler
Table height	h	Meter stick
Horizontal displacement	x	Meter stick

Secure the launcher on a horizontal lab table so that the exit end of the launcher is at the edge of the table. Measure the height (h) of the lab table surface above the lab floor. With multiple trials for each compression, push the sphere back to positions A, B, and C, measuring each compression (d). For each trial, release the launcher and measure the horizontal distance (x) along the floor that the sphere travels in flight from the lab table edge to the landing position.



3c. Make a graph with horizontal flight distance (x) on the y-axis and spring compression distance (d) on the x-axis. If the regression line is linear, it suggests the spring constant of the spring remains constant at various compression distances.

3d.



4a. $P = \frac{MgH}{\Delta t}$

4b. In parallel with R_1. Adding a second resistor in parallel with the first resistor decreases the net resistance of the resistors.

Let V_B represent the voltage of the battery

Let V_M represent the voltage across the motor

Let R represent the net resistance of the resistors in the circuit

Let R_M represent the resistance of the motor

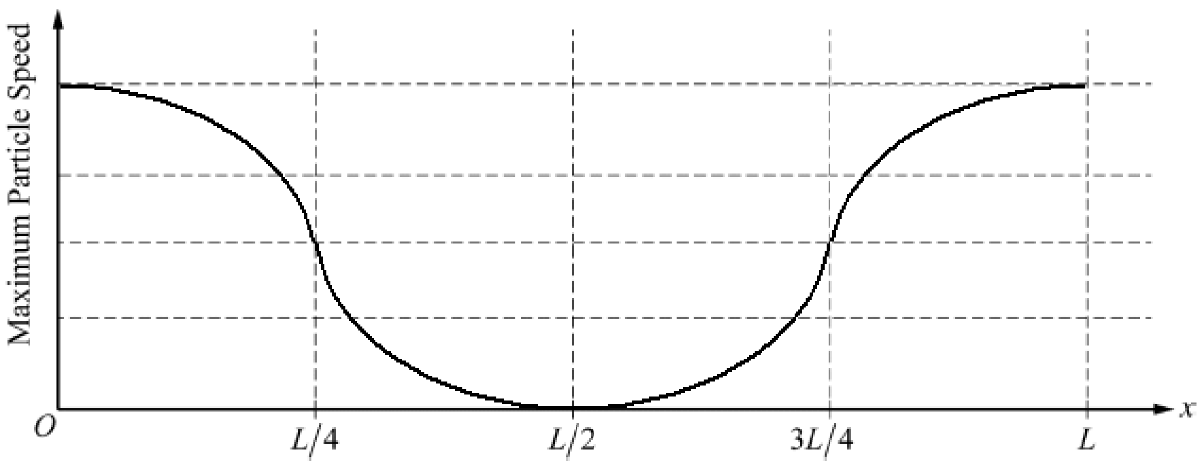
Let I represent current through the motor

By Kirchhoff's loop rule, $V_M = V_B - I \cdot (R + R_M)$. Decreasing R increases the voltage across the motor, thus increasing its power. If $P = \frac{MgH}{\Delta t}$ and MgH is constant in all situations, the higher the motor power, the lesser the time span.

5a. $\lambda = \frac{v}{\upsilon} = \frac{340}{512} = 0.664$m

L = $\frac{1}{2}\lambda$ so L = 0.332m

5b.



5c. $\lambda = 4L = 1.328$m

$\upsilon = \frac{v}{\lambda} = \frac{1005}{1.328} = 757$Hz