Question 1

1.a.i. Initially, the force of gravity on block 2 is greater than the tension of the string on block 2. If the net force is downwards, the acceleration is downwards. If the velocity is initially zero, the block will descend and speed-up. Eventually, the tension force is greater than the force of gravity and the acceleration is upwards. This acceleration causes the velocity to gradually transition from negative to zero when block 2 is again stationary.

1.a.ii.

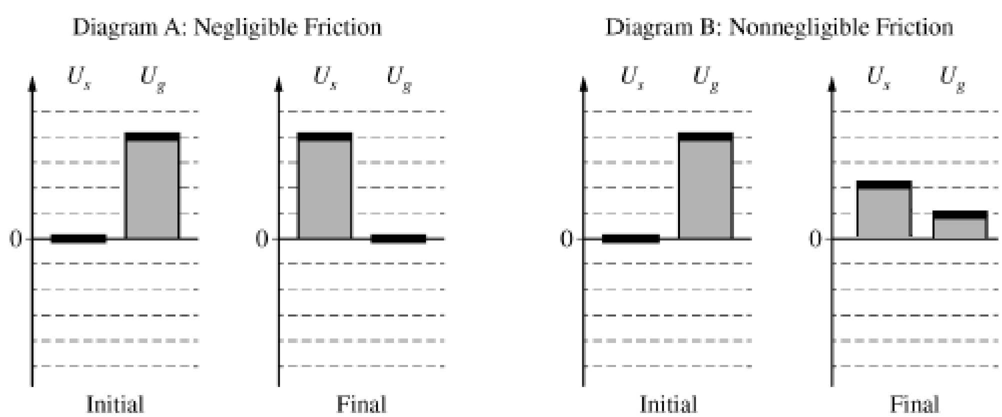
$\Delta E = 0$

$\frac{1}{2} \cdot k_0 \cdot \Delta y^2 - M_2 \cdot g \cdot \Delta y = 0$

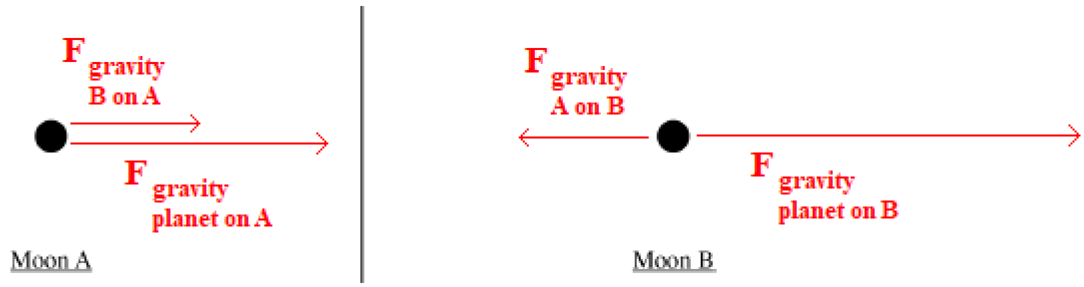
$\Delta y = \frac{2 \cdot M_2 g}{k_0}$

1.b. Does not change if the pully has negligible mass. There is no external work input to the system because no external forces act on the blocks or spring or Earth over a displacement and there are no other sources of energy transfer. If the pulley has non-negligible mass, there is a decrease in the mechanical energy caused by the work input from the two ends of the string.

1.c.



2.a.



2.b.i. The net force on A would be greater than the net force on B if R_B is much greater than ($R_B - R_A$). If this were true, then the force of gravity on the two moons from the planet would be nearly equal, called $|F_p|$. The net force on A would then be $|F_p| + |F_{B\ on\ A}|$ and the net force on B would be $|F_p| - |F_{B\ on\ A}|$.

2.b.ii. The net force on B would be greater than the net force on A if ($R_B - R_A$) is much greater than R_B. If this were true, then the force of gravity between the two moons would be very small and approaching zero. The net force on B would therefore be much greater than the net force on A because it is effectively only from the planet which is much closer to B.

2.c.

The net force F_A exerted on Moon A

$$\frac{G \cdot m_p m_0}{R_A^2} + \frac{G \cdot m_0^2}{(R_A - R_B)^2}$$

The net force F_B exerted on Moon B

$$\frac{G \cdot m_p m_0}{R_B^2} - \frac{G \cdot m_0^2}{(R_A - R_B)^2}$$

d.i. Yes. As $R_A - R_B$ approaches zero, F_A continuously increases while F_B approaches zero.

d.ii. Yes. As R_B approaches zero, ($R_A - R_B$) increases, decreasing F_A while increasing F_B.

3.a.

Quantity to be measured	Symbol for Quantity	Equipment for measurement	Procedure
Block mass	m_B	Mass scale	Tare the scale. Place the block on the scale. Record the reading and convert to kg.
Block descent distance	Δy	Meterstick	Place the zero of the meterstick on the floor and see where the base of the block is along the meterstick.
Block descent time	Δt	Stopwatch	Zero the stopwatch. Begin the stopwatch when the block is released from rest. Stop the stopwatch when the block strikes the floor. Repeat ten times and average these times.

3.b. Use the equation for linear kinetic energy

$K = ½\cdot m_B\cdot v^2$

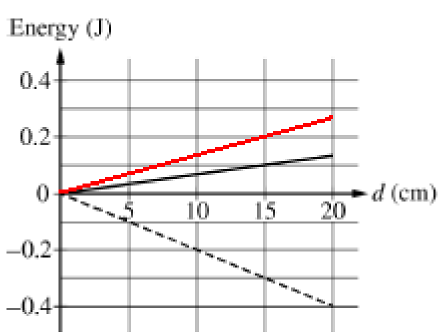
where $v = 2\cdot\frac{\Delta y}{\Delta t}$

To determine the change in gravitational potential energy, use

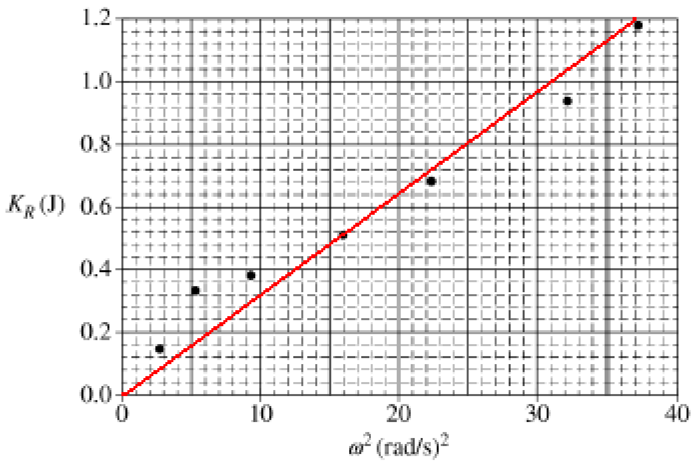
$\Delta U = m_B\cdot g\cdot \Delta y$

where $g = 9.8 m/s^2$

3.c.



3.d.i.



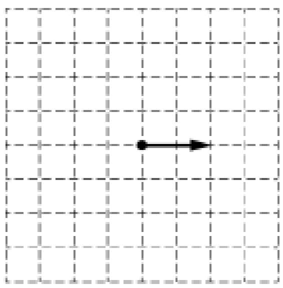
3.d.ii.

$K_R = ½ \cdot I \cdot \omega^2$

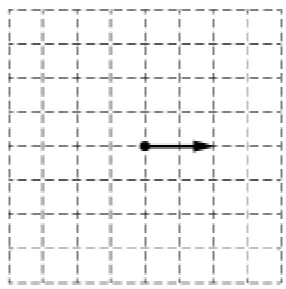
so $I = 2 \cdot \frac{K_R}{\omega^2}$

$I = 2 \cdot$[slope] = .0645kg·m^2

4.a.



Case A: Momentum of
Clay-Block System
Immediately After Collision



Case B: Momentum of
Sphere-Block System
Immediately After Collision

4.b. Block B lands on the floor at a greater horizontal distance from the edge of the table compared to block A.

For both collisions, linear momentum is conserved in the x-dimension. The change in horizontal momentum for the projectile and block system is therefore zero. If the clay and sphere have the same mass and the sphere has a greater negative change in velocity, the sphere has a greater negative change in momentum. To keep the net change zero, Block B must have a greater positive change in momentum. If blocks A and B have the same mass, block B must leave the table with a greater positive velocity.

Both blocks leave the table with a vertical velocity of zero and both fall the same distance with the same acceleration. By the equation $\Delta y = v_0 \cdot \Delta t + ½ a \cdot \Delta t^2$, both will take the same time to land. If block B is traveling faster horizontally during this time, it must travel a greater horizontal distance in flight.

5.a.

$T = 2\pi \cdot \sqrt{\frac{m}{k}}$

$1.25s = 6.28 \cdot \sqrt{\frac{0.50}{k}}$

k = 12.62 N/m

5.b.i. At 0.75s and 1.13s, the slope of the graph appears to be approximately the same. The slope of this graph is the velocity, so with the same mass and same velocity, by $K = \frac{1}{2} \cdot m \cdot v^2$, the kinetic energies are the same.

5.b.ii. The potential energy of the system is the sum of gravitational potential energy and spring potential energy. The sum remains the same because the gravitational potential energy decreases from 0.75s to 1.13s as the height in mgh decreases, but the spring potential energy increases from 0.75s to 1.13s as the x in $\frac{1}{2} \cdot k \cdot \Delta x^2$ increases.

5.c.i. Originally, the weight descends from 1.0m to an equilibrium position of 0.60m. With a spring constant four times greater, it would only descend 0.10m to an equilibrium position of 0.90m.

5.c.ii.

Draw a graph that begins with a position of 85cm at time zero. The curve should then oscillate as a -cos function with a minimum of 85cm, a maximum of 95cm, and a period of 0.625s.