AP® CollegeBoard

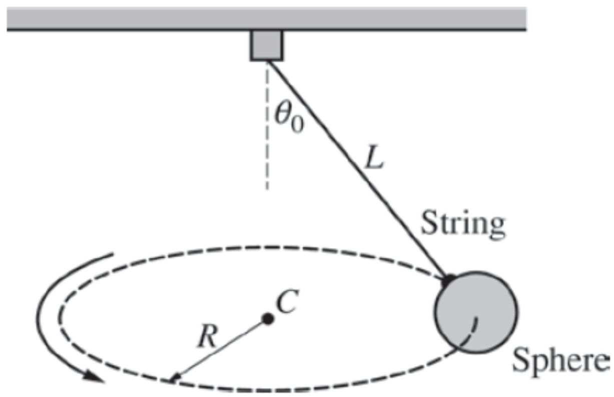
# 2020 Exam Sample Questions

AP® PHYSICS 1

## 2020 Exam SAMPLE Question 1

(Adapted from: AP® Physics 1 Course and Exam Description FRQ 1)

**Allotted time: 25 minutes (+ 5 minutes to submit)**




A small sphere of mass $M$ is suspended by a string of length $L$. The sphere is made to move in a horizontal circle of radius $R$ at a constant speed, as shown above. The center of the circle is labeled point $C$, and the string makes angle $\theta_0$ with the vertical.

Two students are discussing the motion of the sphere and make the following statements.

**Student 1**: None of the forces exerted on the sphere are in the direction of point $C$, the center of the circular path. Therefore, I don't see how there can be a centripetal force exerted on the sphere to make it move in a circle.

**Student 2**: I see another problem. The tension force exerted by the string is at an angle from the vertical. Therefore, its vertical component must be less than the weight $Mg$ of the sphere. That means the net force on the sphere has a downward vertical component, and the sphere should move downward as well as moving around in a circle.

(a) What is one aspect of Student 1's reasoning that is incorrect? Explain why.

(b) What is one aspect of Student 2's reasoning that is incorrect? Explain why.

Student 3 correctly derives the equations $F_{net} = F_T\left(\frac{R}{L}\right)$ and $Mg = F_T\left(\frac{\sqrt{L^2 - R^2}}{L}\right)$ to relate the tension force $F_T$ to the net force $F_{net}$ and the other quantities.

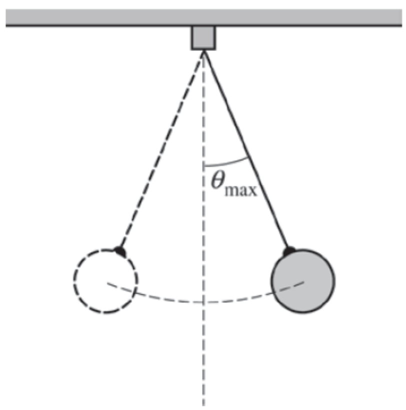
(c) Explain how one of the equations can be used to challenge Student 1's claim.

(d) Explain how one of the equations can be used to challenge Student 2's claim.

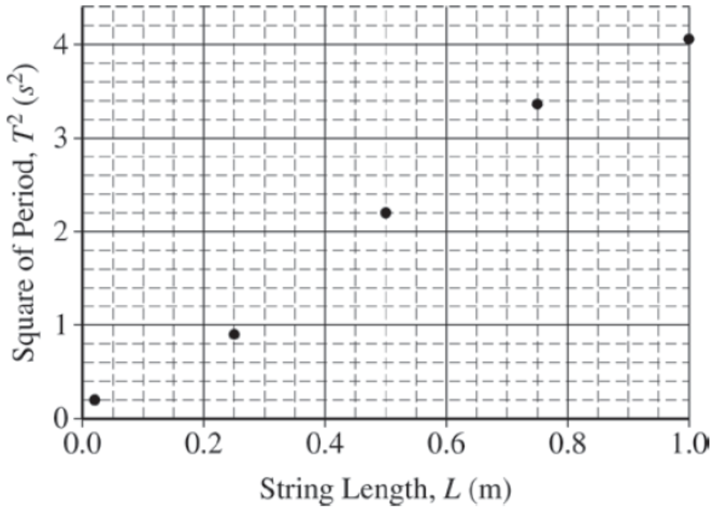
The students observe that the radius $R$ increases as the speed $v$ of the sphere increases. Together, they derive the equation $R = v\sqrt{\frac{L}{g}}$ to calculate the radius of the circle $R$ followed by the sphere if its speed is $v$.

(e) Regardless of whether this equation is correct or incorrect, does it plausibly model the students' observation about the relationship between $R$ and $v$? Why or why not?

(f) This equation does not correctly model the relationship between $R$ and $v$ if $v$ is very fast. Explain why.




Instead of moving in a horizontal circle, the sphere now moves in a vertical plane so that it is a simple pendulum, as shown above. The maximum angle $\theta_{max}$ that the string makes from the vertical can be assumed to be small. The graph below shows data for the square of the pendulum period $T$ as a function of string length $L$.

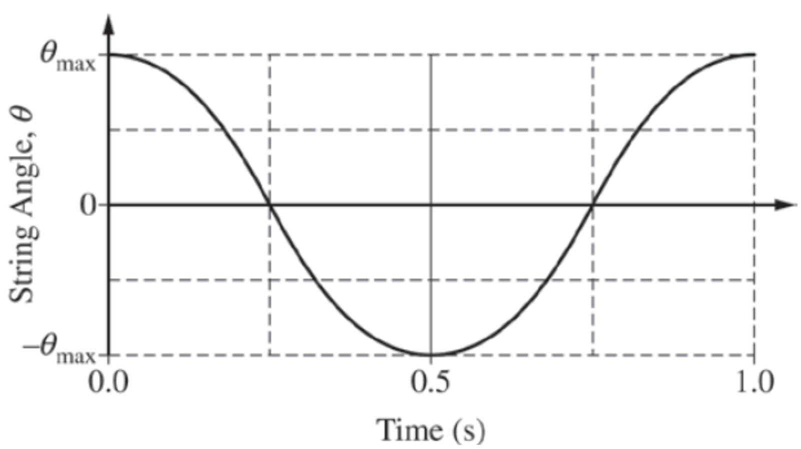



Explain how the above graph would change under each of the following circumstances. Justify your answers.

(g) The mass of the sphere is increased.

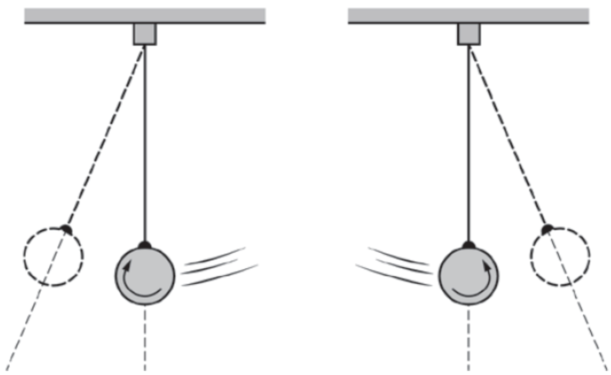
(h) The maximum angle $\theta_{max}$ is decreased.

(i) The pendulum is taken to the Moon.




(j) The graph above shows the angle theta from the vertical as a function of time for the pendulum. Explain how this graph shows evidence of a net force acting on the sphere, and how it shows that this net force is a restoring force.

As the sphere swings back and forth, it must also rotate a small amount during each swing. The figures below indicate the direction that the sphere rotates as it is swinging in each direction.



(k) In order for the sphere's rotation to change direction, a torque must be exerted on the sphere. When the sphere is at its maximum rightward displacement, what is the direction (clockwise or counterclockwise) of the torque exerted on the sphere with respect to the point of attachment between the sphere and string? Briefly state why the torque is in the direction you indicated.

## 2020 Exam Sample Question 2

(Adapted from: AP Physics 1 Course and Exam Description FRQ 2)

**Allotted time: 15 minutes (+ 5 minutes to submit)**

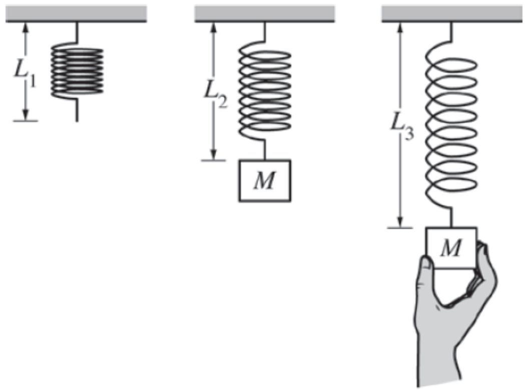



Figure 1 Figure 2 Figure 3

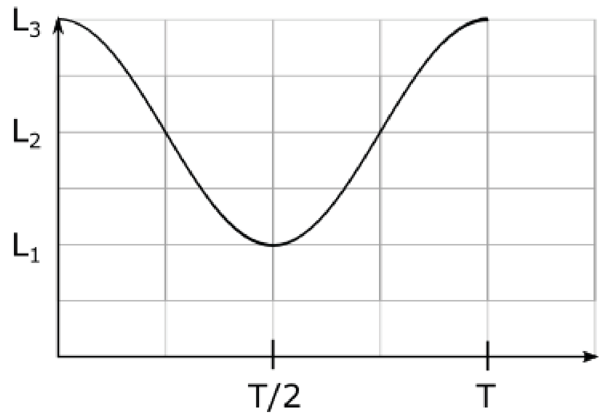
A spring with unstretched length $L_1$ is hung vertically, with the top end fixed in place, as shown in Figure 1 above. A block of mass $M$ is attached to the bottom of the spring, as shown in Figure 2, and the spring has length $L_2 > L_1$ when the block hangs at rest. The block is then pulled downward and held in place so that the spring is stretched to a length $L_3 > L_2$, as shown in Figure 3.

The student releases the block. Consider the time during which the block is moving upward toward its equilibrium position and the spring length is still longer than $L_2$. Indicate whether the total mechanical energy is increasing, decreasing, or constant for each of the systems listed below and explain why.

(a) System 1: The block (energy E1)

(b) System 2: The block and the spring (energy E2)

(c) System 3: The block and the Earth (energy E3)




(d) The block is released at time $t = 0$. The length of the spring is shown in the graph above as a function of time. During which interval(s), if any, is the weight force acting on the block greater than the spring force acting on the block? Explain your reasoning.

(e) When the block reaches its lowest point after oscillating several times, the student attaches a new block of mass $m < M$ to the block of mass $M$ without exerting any noticeable force to the block of mass $M$ or changing the energy stored in the spring at that instant. In a clear, coherent, paragraph-length response that may reference equations, explain how the graph of length vs. time will change and why.