2020 Exam Sample Questions

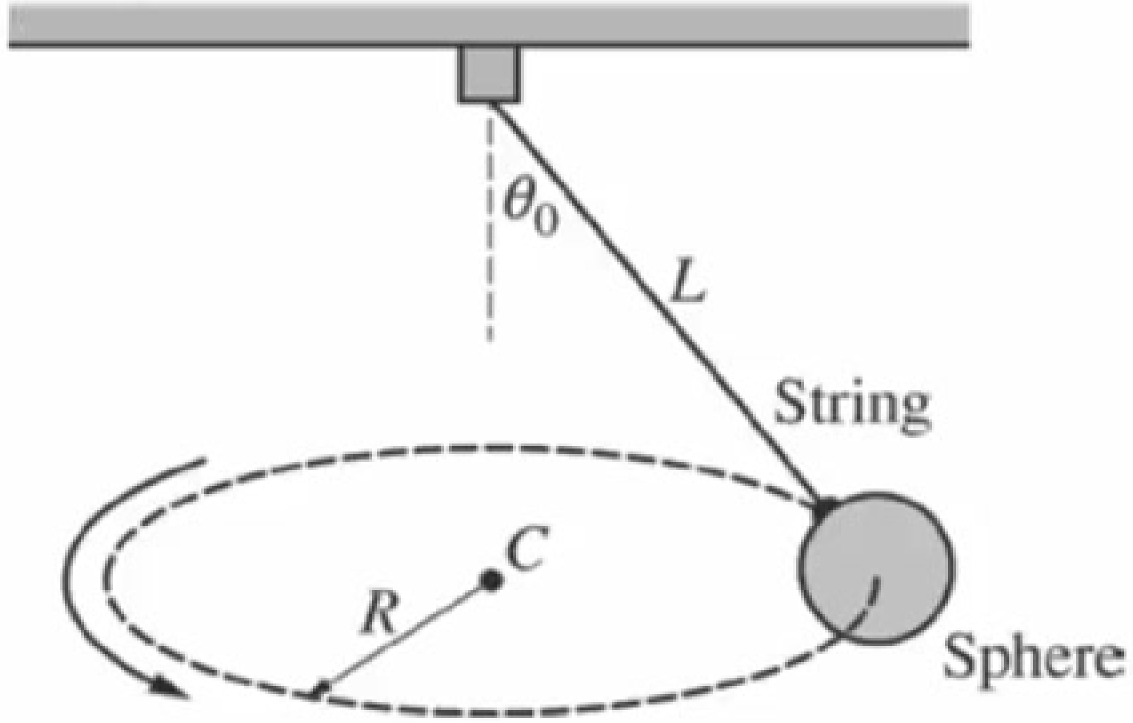
AP® PHYSICS 1

Answers

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 θ_0 with the vertical.

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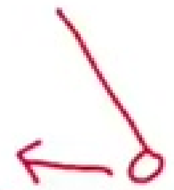

$F_{Tx} = F_c$

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 thinks F_c must come from a separate Force. The horizontal component of tension is toward the center which is the F_c.

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.

Student was incorrect in thinking that the vertical component of $F_T < Mg$. Question says its moving in a horizontal path. No motion in y direction.

(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.

$F_{net\,y} = 0$

$F_{net\,y} = Mg - F_{Ty}$

$Mg = F$

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.

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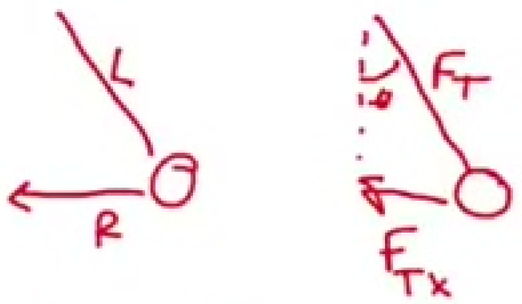

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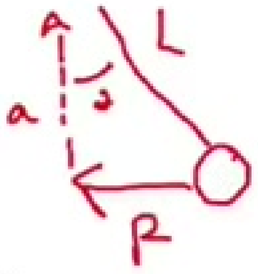

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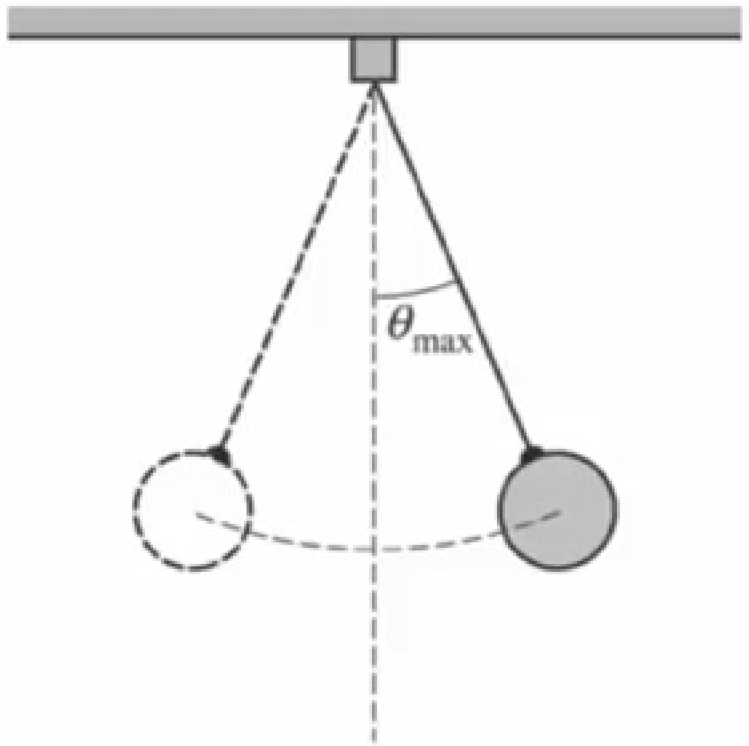
The students observe that the radius R increases as the speed v of the sphere increases. Together, they derive the equation $R = v\sqrt{\frac{L}{g}}$ to calculate the radius of the circle R followed by the sphere if its speed is v.

(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.



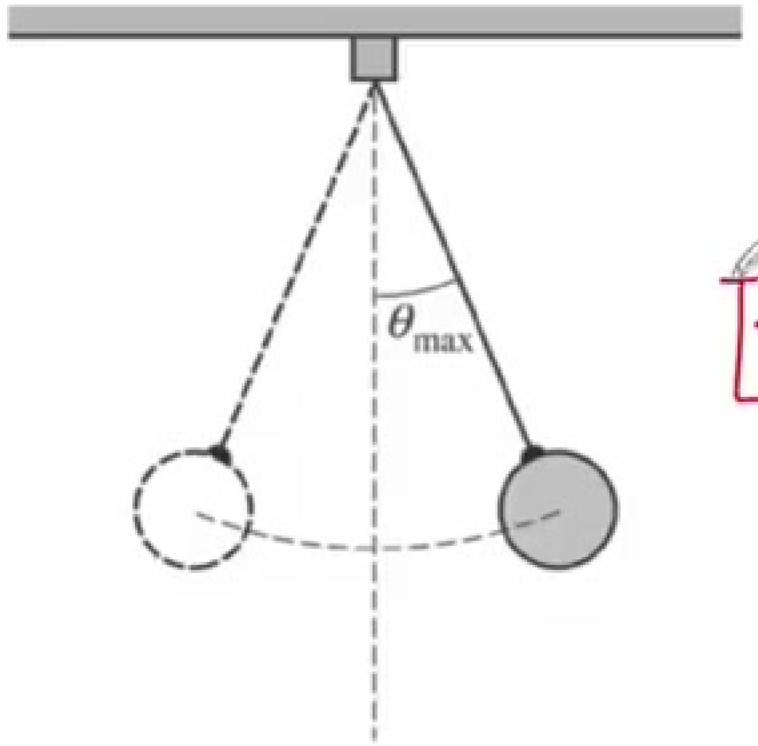
Instead of moving in a horizontal circle, the sphere now moves in a vertical plane so that it is a simple pendulum, as shown above. The maximum angle θ_{max} that the

$\sqrt{\frac{L}{g}}$ = constant

↑ $R = \overset{\uparrow}{v}(c)$

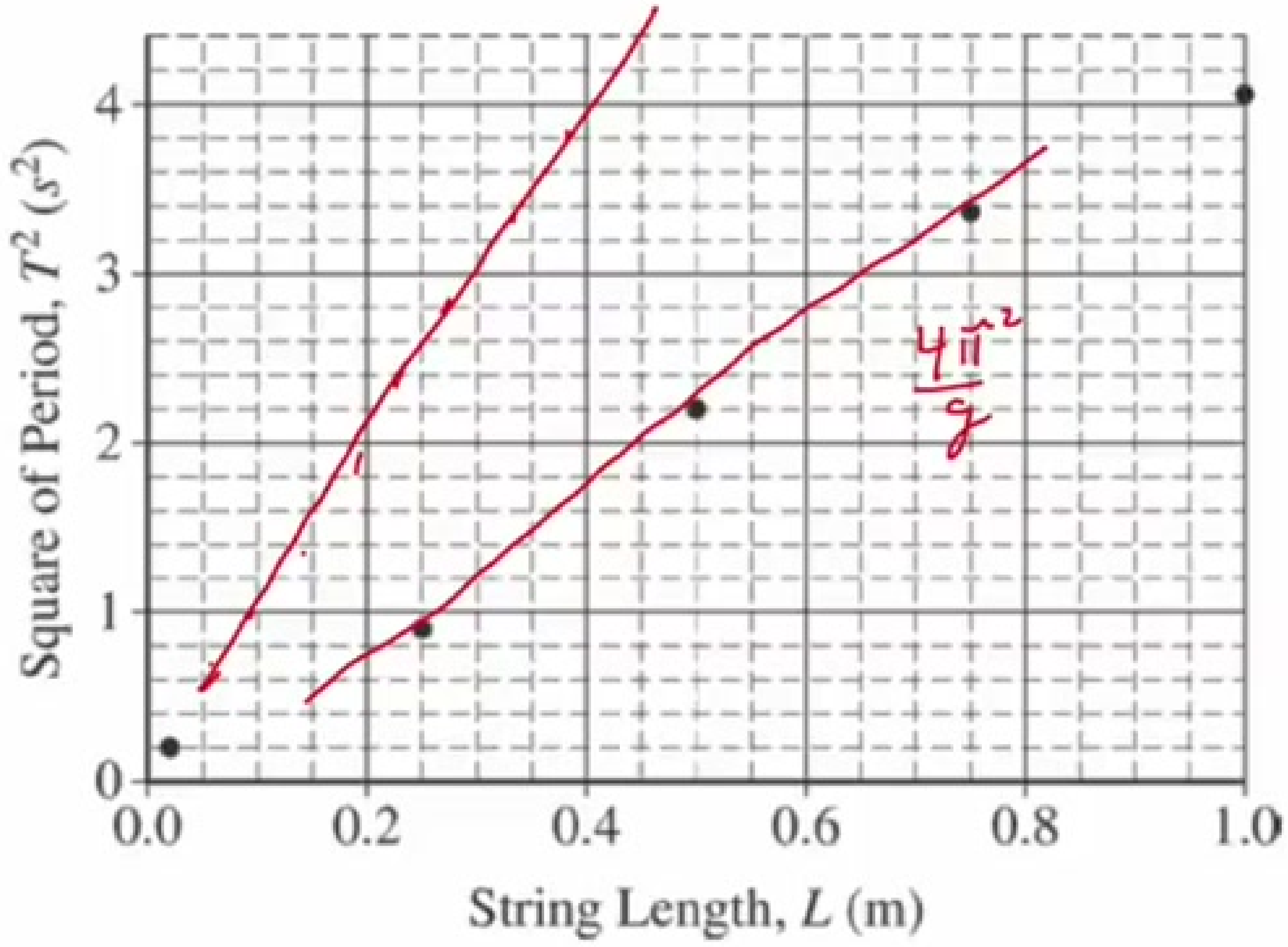
No... L constraints the system.
R can only be as big as L. Therefore V can c

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



$\sin\theta = \theta$

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 θ_{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.



$T_p = 2\pi\sqrt{\frac{L}{g}}$

$T_p^2 = \frac{4\pi^2 L}{g} + 0$

$y = m x + 0$

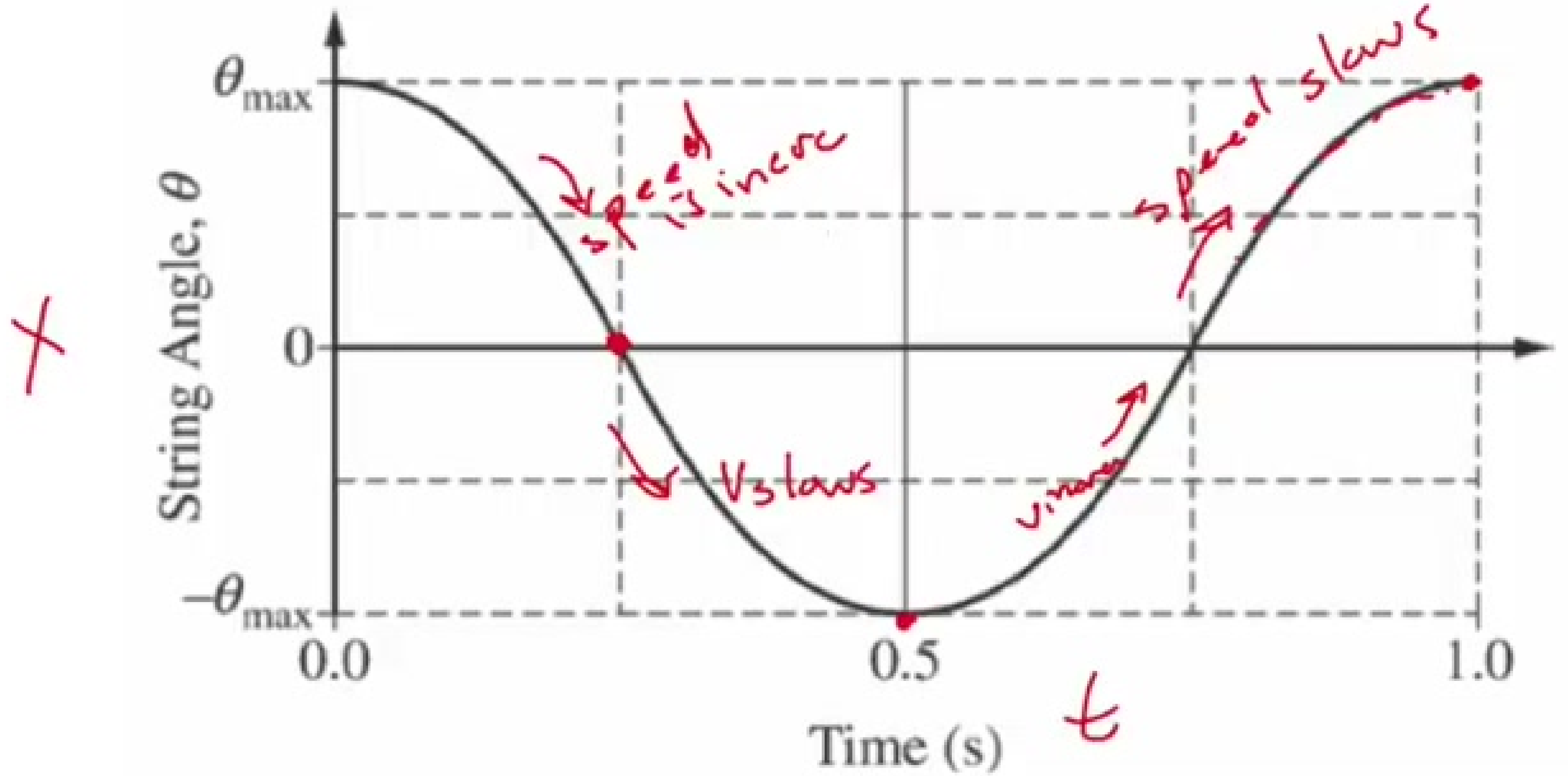
$g_{Moon} < g_{Earth}$

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

(g) The mass of the sphere is increased. No change in slope .. mass is not it the formula.

(h) The maximum angle θ_{max} is decreased. No chang in slope .. θ is not in the period formula.

(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.

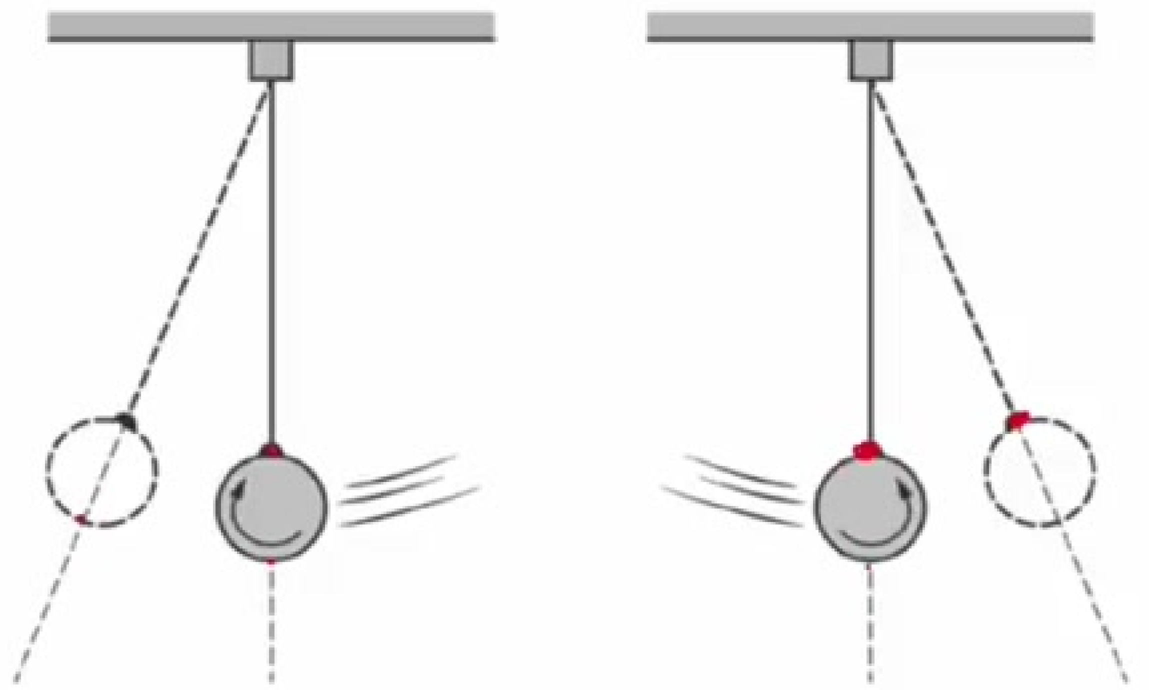
x vs t graph

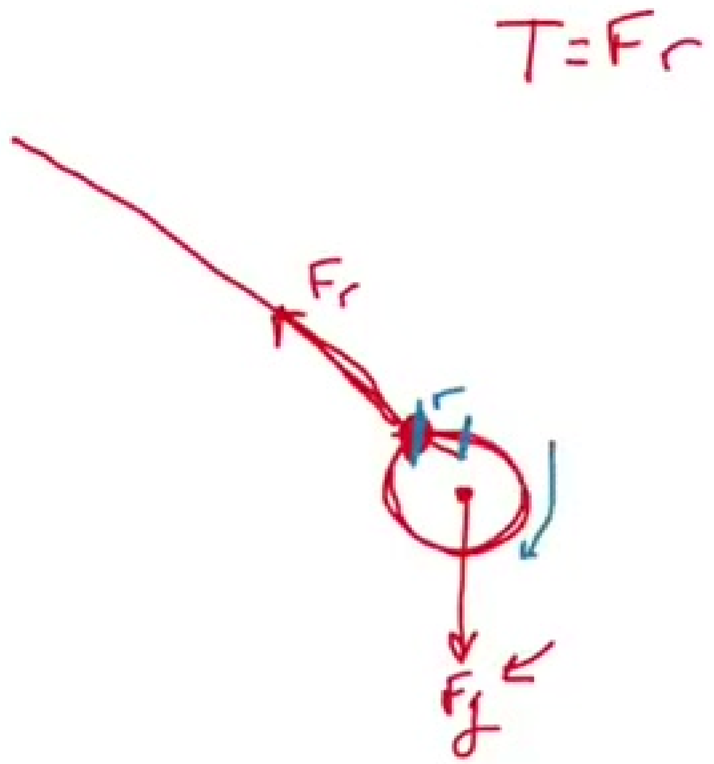
Slope of x vs t => velocity

- velocity is changing
- acceleration > 0 m/s²
- acceleration must be caused by an F_{Net}

- In simple harmonic motion a restoring force is always present. And since a restoring force wants to bring an object to equilibrium we can see this on the graph by looking at the velocities

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.