

# Universal Physics Journal

Question 10: The direction of the pendulum's overall force is... ?

## The Pendulum Event

The following survey question was asked of the Physics students of several colleges. The results of the survey caused the survey's author great concern since the students, more often than not, failed to give the expected answer. An article on the results by the survey's author was printed in a well-known Physics magazine. The magazine received several letters challenging the validity of the expected answer. The author defended his position with apparent success. Since I still disagreed with the expected answer, I decided to submit an analysis to the magazine. My analysis included a drawing of the event. Overall my submission was the opposite of brief. The magazine's editor politely explained that he could not print my analysis of the pendulum event due to the lack of space.

## The Survey Question

A swinging pendulum bob is, for a brief instant, directly below its point of support. Draw an arrow indicating the direction of the overall force on the bob at this instant.

## The Expected Answer

The student draws an upward-directed arrow over the bob in the direction of its support.

## The Analysis

Is the bob really experiencing an "overall" upward-directed force when it is at the bottom of its swing? I wonder. Before beginning, I will drill a small hole up through the center of the bob, hacksaw the bob horizontally in two, tie a large knot in one end of a rubber strand, thread the free end up through the holes in both parts of the bob, and pin the rubber strand into place at the point where it exits the top of the bob while applying sufficient tension on the strand so the bob's lower portion is just barely forced into contact with the bob's upper portion when the non-swinging bob is freely hanging below its support.

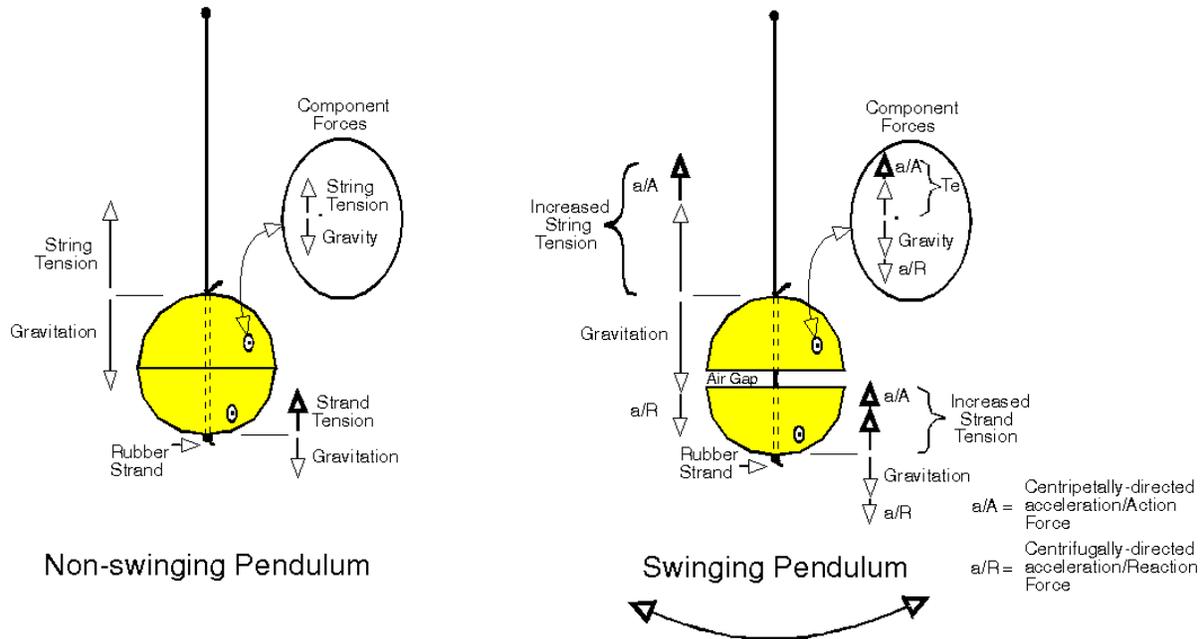
Understand these things. I see force as an absolute push or pull that is being experienced by an object or portions thereof. I recognize that a reaction force does nothing to reduce or prevent an action force from causing an event. A reaction force merely serves to provide support for the action force so that it can exist as the cause of both the reaction force and the event. Somewhat like Newton, I see but two states of motion for an object. Either the object is in (1) the inactive state of motion where acceleration is absent due solely to the absence of a net acceleration-causing action force, or the object is in (2) the active state of motion where acceleration is present due solely to the presence of a net acceleration-causing action force.

## The Non-Swinging, Non-Accelerating Pendulum

When the bob is not swinging, the upward-directed non-accelerative tension force from the string is present and opposed by the cumulative total of the downward-directed non-accelerative gravitational forces from each of the myriad of components of the bob's matter. I see these two opposing forces as non-accelerative for neither is causing nor reacting to any noticeable acceleration for the bob. I see the bob's gravitational force as coming from each of its individual

# The Pendulum Event

drawing by Ethan Skyler



components of matter since the removal of even one atom from the bob will cause a reduction in the bob's gravitational force against the string. Thus here in this inactive (non-accelerating) event, the upward tension force on the bob's matter is not an "overall" force since in the end it is opposed by the cumulative total of all the downward forces of gravity in Earth's direction being generated within each of the bob's myriad of components of matter.

## The Swinging, Accelerating Pendulum

During the bob's swing, at the moment when it is directly below its point of suspension, the previous two non-accelerative forces are both still measurably present at the contact point between the bob and the string. But here in this active (accelerating) event, additional forces are now present as indicated by the increased mutual contact force between the string and the bob. A new upward or inward-directed acceleration/Action force is acting as the cause of the bob's changing direction of observed motion as it travels along an arc while continually accelerating away from a hypothetical straight-line motion tangent to that arc. I see this new inward force as an acceleration/Action force for it is the force acting as the cause of the bob's inward-directed acceleration. I also see a visible gap between the bob's two parts at the bottom of the bob's swing with this gap disappearing as the bob approaches the top of its swing.

I think it is the author's position that this new inward-directed acceleration/Action force is an "overall" force on the bob since no opposing outward-directed force is thought to be present. Is this position true? First of all, due to the "mutual pressure between contacting objects", as

identified so long ago by Isaac Newton in PRINCIPIA, one must accept that as much as the string is pulling inward with an increased force on the swinging bob, the bob is now pulling outward with an increased force on the string. I see this as an indication of the presence of a new, equal in magnitude and opposite in direction, acceleration/Reaction force from the bob. I see this new outward-directed force as an acceleration/Reaction force for it is present only during the bob's inward-directed acceleration and caused by and reacting in support of the previously described inward-directed acceleration/Action force from the string. Like gravitation force, I see the bob's acceleration/Reaction force also as being generated within each of its accelerating components of matter since the removal of even one atom from the bob will cause a reduction in both the string's acceleration/Action force against the bob and the cumulative total of the bob's acceleration/Reaction force against the string.

Is there any other evidence that supports my recognition of the bob's acceleration/Reaction force? In order for the new inward-directed acceleration/Action force to be an "overall" force on the bob there must be no new outward-directed force having an effect upon the bob's matter. May I direct your attention to the air gap visibly present between the bob's two parts at the bottom of its swing? Here the bob's upper part is clearly having to pull inward harder using a portion of the new acceleration/Action force from the string that it is transferring down the rubber strand to the bob's lower part to act as the cause of acceleration for the lower part along the arc. The strand is only capable of exerting this greater inward pull when its length is increased which becomes a visual indication of the presence of a greater supporting outward pull from the bob's lower part. I see this as the reason for the gap, which, by the way, will grow wider if the bob is cut with more of the bob's matter located in the lower part.

According to Newton's recognition of "mutual pressure", as much as the bob's upper part pulls along the rubber strand with a new inward-directed acceleration/Action force on the lower part, the bob's lower part pulls with a new outward-directed acceleration/Reaction force of equal magnitude and opposite direction on the upper part. Thus I think it is logical to recognize that the now-visible gap between the bob's two parts is a sure indication of the presence of this new outward-directed force being impressed by the bob's lower part upon its upper part during the bob's acceleration away from the arc's tangent. If the bob's lower part is sliced into smaller and smaller pieces, the presence of outward a/R forces will continue to be revealed between the slices. In total, this outward a/R force, that is equally present within the solid bob's matter, is caused by and reacts in support of the inward a/A force from the string.

When in the vertical position of swing, the bob's new downward a/R force is measurably equal to the string's new upward a/A force as indicated by the increased "mutual pressure" between the string and the bob. Thus no "overall" or unopposed force on the bob in the upward direction can, from my perspective, exist. I see all forces present in this accelerative event as being opposed (supported) by equal forces that are measurably present. Thus the question where students are asked to "draw an arrow showing the direction of the overall force on the bob" is, in my mind, a misleading question for the student is led by the question to think that an "overall" force in some direction does indeed exist. It is my understanding that no "overall" force exists at any time during this pendulum event nor can one possibly exist at any time during any other event.

In the author's clarification, he takes the position that Isaac Newton's LAW I predicts that an object's acceleration requires the presence of an "overall" force.

### **Newton's LAW I from PRINCIPIA**

"Every body continues in its state of rest, or of uniform motion in a right line, unless it is compelled to change that state by forces impressed upon it."

I do not see anything in LAW I that indicates that the "forces impressed upon" the body represent an "overall" force that is thought by Newton to act on the accelerating body without the presence of supporting reaction forces from the body. In fact a reading of Newton's LAW III reveals that Newton clearly understood every action force, such as the acceleration/Action force impressed upon the body in LAW I, or the inward a/A force impressed by the string upon the swinging pendulum bob, is always opposed by an equal reaction force, such as the supporting outward a/R force from the bob's accelerating components of matter as revealed in the pendulum experiment. Here in our swinging bob event it is clear to me that both acceleration/Action forces and acceleration/Reaction forces are "impressed" within or upon the accelerating bob just as Newton's LAW I predicts is so with its use of the plural word "forces". I see the equal opposition between such mutual forces as being in full agreement with Newton's recognition of the "mutual pressure" between contacting objects in LAW III. Further I see every indication that Newton intended these Universal Laws to work not separately but in conjunction with each other.

### **Conclusion**

It is my opinion that no "overall", net, unbalanced, or unopposed force can possibly exist. I see this opinion as being fully supported by logic, by experiment, by common sense, and finally by the strength and depth of Isaac Newton's classical work on the science known today as Physics.

Regarding the survey question, I think more meaningful results will be obtained if students are asked: "When the bob is at the bottom of its swing, do you think there exists an action force causing acceleration for the bob? If not, check [ ] No. If yes, check [ ] Yes and draw an arrow indicating the direction of the bob's acceleration."

Sincerely,

Ethan Skyler  
November 12, 2001

(I am certain the author of the Pendulum Event survey, was totally dismayed that instead of focusing on reasons why the educational system had failed to prepare these students to answer the pendulum survey question as expected, the respondents to his magazine article were more concerned with the validity of the author's question and his expected answer. But now that we know the answer he expected was itself incorrect, perhaps many of the students responding to the survey would have given the correct answer had they been expected to answer a question that was itself correct. To me this means that there still exists the possibility that the strength of their understandings of Physical events is greater than the conclusion reached by the author of the survey.)

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