

CHAPTER 13

A Ghost Story

Mythologies & Ghostologies

13.00 Prelude

Just as we have neighbors, objects and systems-of-objects also have neighbors

Just as we have myths and ghosts in our civilized environment, objects and systems-of-objects also have myths and ghosts, woven into the fabric of their environment and culture, no less enchanting and captivating than ours!

In physics, we always have *objects* (and *systems-of-objects*)

13.01 Defining Myths and Ghosts

According to authentic national dictionaries, a *myth* is described as (among others):

- (i) a fictitious or imaginary person or thing
- (ii) an exaggerated or idealized conception of a person or thing

As for ghosts, we find the following description, (among others):

- (i) appearing or manifesting but not actually existing

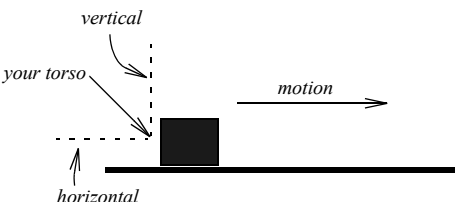
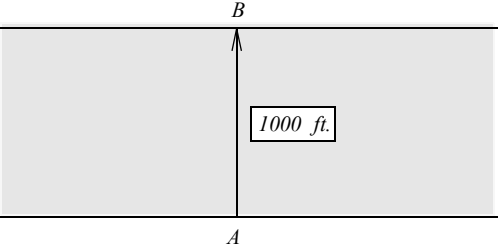
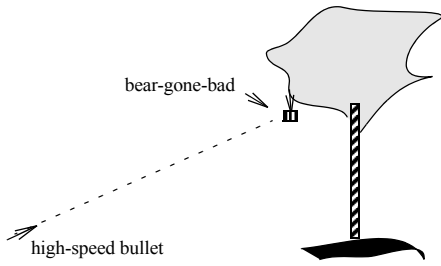
13.02 Myths and Ghosts: (1) Affective Judgement

Consider the following seven situations and ponder over the referenced question in each case. Then check with the suggested answers and see for yourself, how many of your answers, based on common sense and affective judgement, are condemned by the *truth*, that we call physics. Your dissatisfaction with the results will introduce you to *myths*.

Table 1: truth or myth?

	Situation	<i>statement (in italics)</i>	<i>affective judgement</i>
1	You throw a ball straight up. It goes up 5 ft. and then falls back 5 ft. into your hands.	The ball went up at a fast speed, and then fell downward at a slower pace. <i>In other words, the ball goes up at a faster speed, and falls back down at a slower speed.</i>	going up faster than falling down <i>How crazy can you be</i>
2	You are playing with a marble on a table top. You push the marble, it rolls on the table and then falls off the table. As you push it randomly, the marble sometime it falls closer to the foot of the table and sometime farther away from it. If you push it hard enough, it may touch the floor at the farthest end of the room.	<i>The farther away from the foot of the table, the marble hits the floor, the longer it stays in air</i>	<i>naturally!</i>
3	Objects of unequal (significant) weights got dropped suddenly and simultaneously.	<i>Heavier ones hit the ground first.</i>	<i>sounds natural to me</i>

Table 1: truth or myth?

	Situation	<i>statement (in italics)</i>	<i>affective judgement</i>
4	<p>You are relocating a box full of books on the floor from one end of the room to the other. You bend your torso, so it is half way between the horizontal and the vertical, and apply a force of push of (say) 100 units to push the box forward.</p> 	<p>We are told that a force, in the manner in which it is applied here, will have only (approximately) 70% effectiveness to push the box in the forward direction. This is OK. It is understandable.</p> <p>So 70 units of our force of push (out of 100 units that we applied), actually pushes the box in the forward direction, along the floor.</p> <p><i>“At the same time, they tell us that, 70 units of our force of push (out of 100 units that we applied), goes waste and does not pull the box in the forward direction, along the floor.”</i></p>	<p>How can there be two 70% parts of unity?</p> <p><i>Are you crazy?</i></p>
5	<p>You swim across a river that is 1000 feet wide. (1000 feet is a little less than one-fifth of one mile.) Water current is not too strong and, starting at A, you reach the opposite side, B, comfortably.</p> 	<p><i>In reaching “B”, straight from “A”, you swam (swimmed?) a length significantly larger than 1000 feet; may be 1200 feet or even 1300 feet.</i></p>	<p>Starting from “A” and arriving at “B”, how would you have travelled more than 1000 feet?</p> <p><i>Are you crazy?</i></p>
6	<p>A high-speed bullet is fired, aimed straight at a bear-gone-bad, sitting on a branch of a tree. Per chance, the bad bear slips off the tree, the same instant as the high-speed bullet is fired, and falls straight down on the ground.</p> 	<p><i>The high-speed bullet keeps streaking through air; straight as aimed, and so the bear-gone-bad escapes the high-speed bullet.</i></p>	<p><i>The lucky bear-gone-bad!</i></p>
7	<p>A hammer fell on an egg. The egg was crushed to smithereens. (smithereens = tiniest pieces)</p>	<p><i>Before turning into smithereens, the egg retaliated and impacted an equally ferocious force, on the hammer</i></p>	<p><i>egg bashing the hammer?</i></p> <p><i>Ha ha-ha!!! you must be joking!!!</i></p>

How would you feel if we told you that all seven of the affectively judged comments are wrong? Logical conclusions and common-sense based arguments get thrown out and flushed down the drain!

The downfall and total failure of affective judgement is the proof of the existence of myths in the world of Newtonian physics. Unholy myths in modern physics (relativity, quantum mechanics) are even more mind-boggling and are even more commonplace

13.02 *Myths and Ghosts: (2) Equilateral Triangle*

One force or a multitude of synchronous forces?

It would probably be a sin, to deny familiarity with an equilateral triangle. However, after reading the following, you may wish you would rather be sinful than face the dreary doings (ghostliness) of the innocent-looking triangle.

Take two identical one-unit long vectors that are oriented at an angle of $\angle\theta = 120^\circ$ with respect to one another. By combining the two, we get a resultant vector which, together with the original two vectors, makes an equilateral triangle, as shown below:

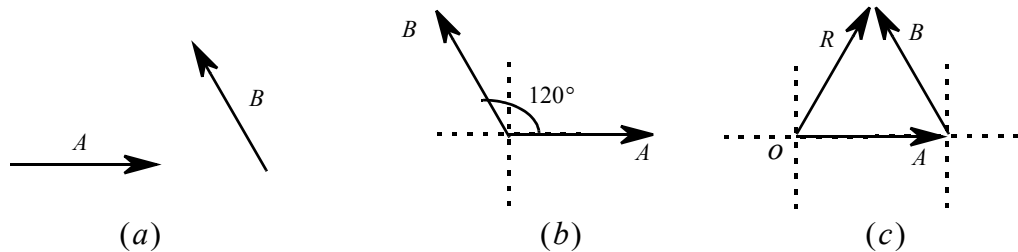


Fig (1) To show that $1 + 1 = 1$

Fig (1a) shows two identical vectors. Fig (1b) shows that the two are indeed at $\angle\theta = 120^\circ$ to each other. In Fig (1c) the two are shown tip-toed and the resultant vector R is drawn. We end up with an equilateral triangle. Being an equilateral triangle, the three sides are of equal length. Vector-wise we will say that $R = A + B$, and magnitude-wise we shall say that $A = B = R = 1$

If two identical hammers (at $\angle\theta = 120^\circ$ to each other), strike a nail (being driven in the wall), symmetrically, with identical force (of say 60 N each), at exactly the same instant of time, the nail will experience *ONLY* one force of magnitude 60 N (directed into the wall).

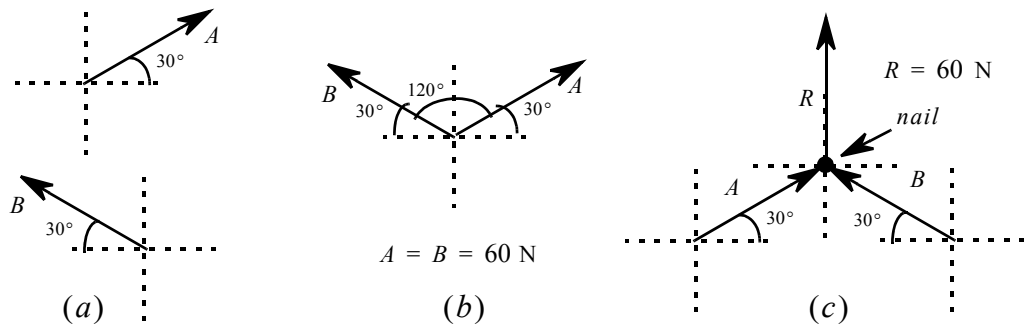


Fig (2) Forces on the Nail

Fig (2a) shows two identical 60 N forces, named A and B . Fig (2b) shows that the two are indeed at $\angle\theta = 120^\circ$ to one another. Fig (2c) shows a nail placed at the origin of a reference frame. Forces A and B are then applied to the nail symmetrically, synchronously. The

nail experiences a resultant force of 60 N, as if there was only one force, directed into the wall! We find that there is absolutely no difference between a single force striking the nail *and* a pair of forces striking the nail as per Fig (2c).

Imagine how immensely difficult it makes life for us. Suppose we are hit at the back of our head or our back itself, so that we did not see who or what hit us. How would we be sure if we were hit by one source-object only or by a pair of identical source-objects, in the manner described above?

If it ended here, we may pressure ourselves to maintain our cool and tolerate having been hit by two bad guys (elements). But alas! It is not the end. What if each of these two forces is made up of two forces in the manner described above? We would have been hit by four bad guys and if each of these four forces is made up of two forces each, we would have been hit by eight bad guys. This continues un-abated and there is no end. It turns out that we are hit by a multitude of bad guys whose number could easily extend to infinity. By the way, it is not necessary that we actually see these forces. They can legally remain invisible to us or be in a dimension of their own.

There is absolutely nothing to contradict this line of argument. Like it or not, believe it or not, but it is a fact that every *force* can be rightfully assumed to be made up of a pair of identical real or imaginary forces, in the manner described above. The procedure leads us to a multitude of unholy forces present, all at the same time.

One force or a multitude of ghostly forces, we have one heck of a myth on our hands.

13.03 *Myths and Ghosts: (3) Center-of-Mass of a Solid Object*

We would refer you, at this time, to the extensive discussion on the concept of the center-of-mass of a solid material object (or of a system-of-objects), presented in the *Concepts* section. We shall highlight some of the features of the centers-of-mass and demonstrate their mythism or ghostliness.

Mythical or real, the center-of-mass point is a fact of life. Its position for a given solid object (or a system-of-objects) can readily be experimentally determined. But it will be a dimensionless point. There will be nothing at this point (a creation of our imagination?), but it will manifest itself as holding the entire mass of the object, thereby rendering the rest of the body of the object, massless (so to speak).

To enhance the mystery associated with the center-of-mass, consider the center-of-mass of a cup (of coffee or tea). The center -of-mass in this case (and similar cases) lies outside the body of the object, hanging somewhere in the interior volume of the cup. So, the entire body of the cup is totally massless. The wretched mass is to be found dumped at a dimensionless point somewhere in the space, beyond the material part of the cup!

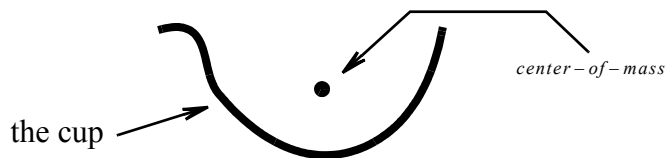


Fig (3) *The Center-of-Mass of a Cup*

It follows from the above that the very concept of the center-of-mass is a myth. As put by Catherine C. Cole, in her book, *The Hole in the Universe*, “The center of gravity (center-of-mass) is a point of zero dimensions at which all the weight (mass) is concentrated. Nothing is there and everything is there”. This statement snugly fits the definition of “ghost”: *appearing or manifesting but not actually existing*.

As the concept of the center-of-mass is a myth, in all of its various forms and activities, we shall be justified in naming it as a *ghost point*

13.04 *Myths and Ghosts: (4) What Keeps the Center-of-Mass on the Trajectory?*

The center-of-mass follows the trajectory of motion, so do the wise fellows of Newtonian physics tell us. Consider a ball thrown in air. The moment it leaves the tip of the boot of the kicker, not only that the trajectory (a parabola) of the ball is computed and carved in space but the center-of-mass of the ball is also glued to this trajectory and come rain, come shine, it will not budge from this path. A typical trajectory is shown in Fig (3) below. This will be true of all projectiles including basket balls, tennis balls, divers jumping off the diving boards into the swimming pools, ice skaters jumping up on the ice, performing somersaults, shells fired from cannons, etc., etc.

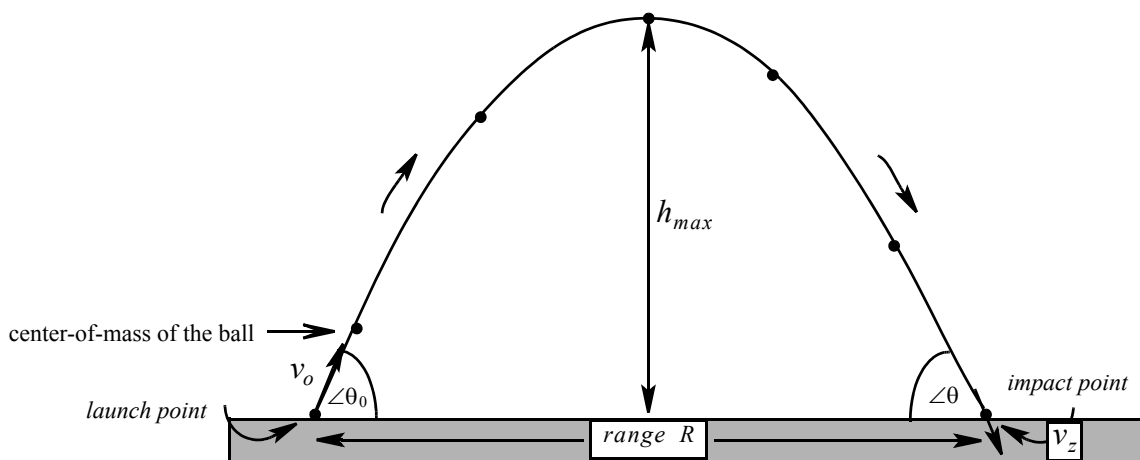


Fig (3) Trajectory is computed and the CM gets glued to it

The glue-ism of the center-of-mass to the trajectory is so immensely important that should the position of the center-of-mass change by some internal mechanism, the whole body of the object will be shifted up or down so the center-of-mass sits squarely on the trajectory. This is true and applicable to performers on ice (in an ice-skating rink), and the divers in swimming pools and all others.

Consider Sheila (nearly 1.80 m tall, with a mass of about 72 kg), a well trained and highly acrobatic diver. She dives from a high-enough diving board into a deep-enough swimming pool. She can manipulate her body-parts to shift her center-of-mass from one position to another. Let us say that at the beginning of the jump, she is straight and then quickly bends her head down and folds her both arms around it. The upper part of the body being heavier, the center-of-mass will be somewhere in her chest area. Then she straightens up, fully extending her arms (above her shoulders) and legs (straight down). The center-of-mass will now be somewhere in the belly area. Finally she folds her legs up and clasps them with her arms. Now the lower part of the body is heavier and the center-of-mass shifts to somewhere in her bottom area. While entering the water, she may straighten up again, so as not to make a big splash (which is hated by the judges). These are shown in the Fig (4) below

To keep the center-of-mass on the trajectory, Sheila's all 72 kg mass had to be moved vertically up and down. This movement has nothing to do with gravity. Suppose the distance between the chest area and the belly area is 25 cm and that between the belly area and the bottom area is 30 cm, then the total distance by which the center-of-mass moved,

(causing the whole body to move), is 65 cm. Remember only the head, the arms and the legs were adjusted or readjusted but not the part of the body from the chest area down to the bottom area. So this distance of 65 cm remained 65 cm, no matter what. This motion is vertically up and down (and not sideways). So, we need a z-mode force, other than the force of gravity, to be able to act in both directions (upward or downward). Remember nothing can move from rest without the application of a force and no amount of internal forces can cause a whole body to move, while in flight. So, how did the bottom area of her torso move upward (against gravity) by 65 cm?

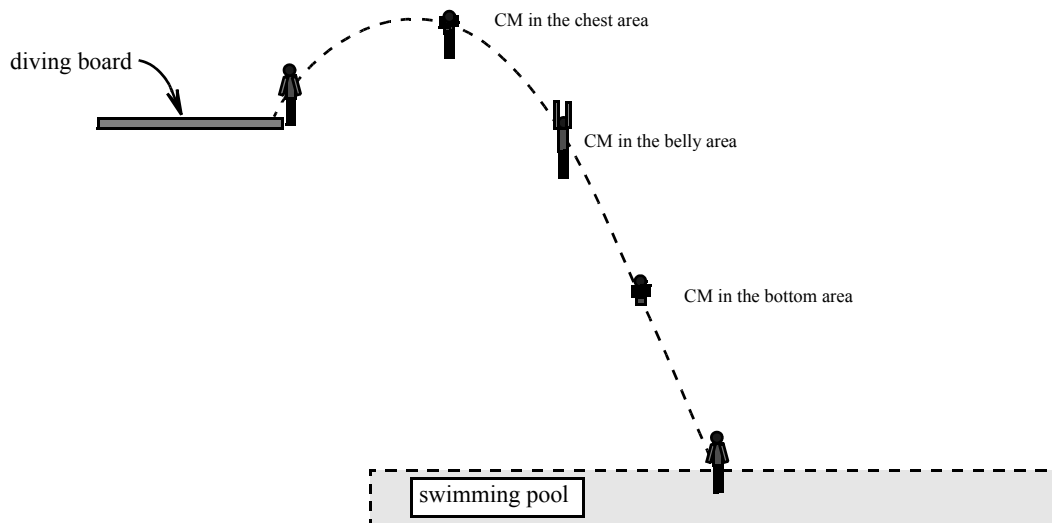


Fig (4) The many positions of the center-of-mass

The same would be true of a lightweight ice-skater. Consider Tequila, an accomplished performer on the ice. While dancing, she makes a sort of long jump and gets airborne. While in air, she can manipulate her arms and legs to raise or lower her center-of-mass. Accordingly, her torso adjusts itself, by moving upward or downward, to keep the blessed center-of-mass on the parabolic trajectory of her jump. Or consider Vanilla, an Olympian high-jumper who always bends her fragile (but highly curvaceous) body into a shallow tea-cup, (at the top of her jump) so as to send her center-of-mass as far down as possible. This raises her torso up by a good number of centimeters (to keep the center-of-mass on the trajectory), allowing her to scale a higher bar. You see, the jumper's body has to go over the bar, not her center-of-mass.

You may think that only human beings can cause the center-of-mass to be relocated. Consider a dummy toy truck (age 12+) with a smooth flat bed, carrying a sturdy box full of ceramic marbles. The assembly is loaded into a spring gun, as shown in Fig (5a). The flat bed being smooth, the box of marbles quickly slides down and rests itself against the rear wall of the truck. As more mass is concentrated at the rear end of the truck, we would expect the center-of-mass to lie in that area. The cannon is fired and the truck shoots out of the barrel. As it passes over the top of the trajectory, the box of marbles slides down the smooth bed and now rests against the wall of the driver's cabin. The concentration of the mass is now in the forward area and the center-of-mass shifts to the front end of the truck. This is shown in Fig (5b). Also shown, in a dotted trajectory, is the position of the truck, had the position of the center-of-mass remained unchanged. The shift in the height of the truck, for the same height of the center-of-mass above ground, is more than obvious. The shift is upward, against gravity. This process is exactly like the one that occurred in case of our athlete friends.

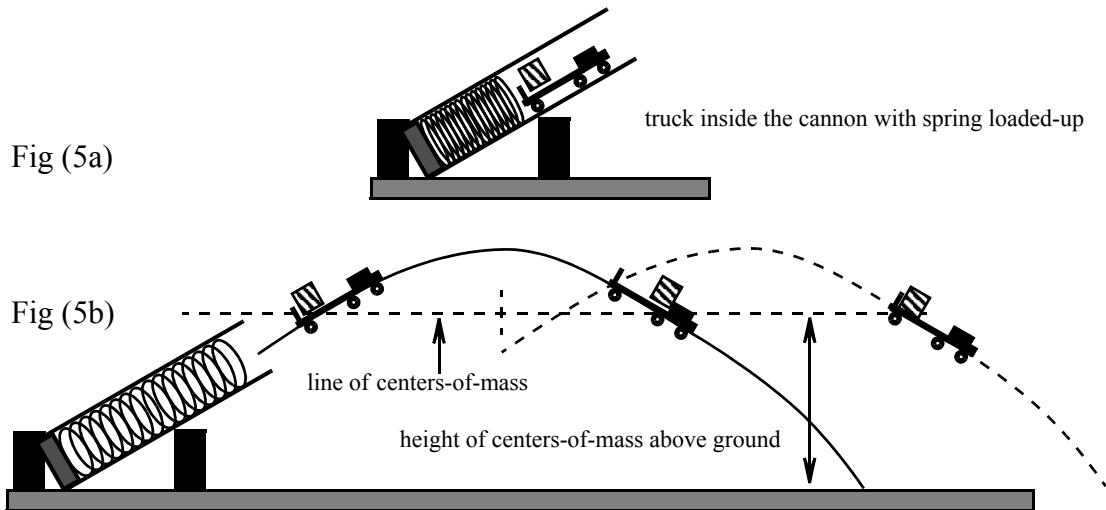


Fig (5) A Toy Truck and a Box of Marbles

Having convinced ourselves of the automated raising and lowering of the bodies of the target-objects in air, in accomplishing the sacred task of maintaining the respective centers-of-mass on the respective trajectories, we now look for the agency (the force) that will let this happen for us. Such a force cannot come from within the body (as a result of internal activities). As you well know, you can jump upward while on the firm ground. Once in mid-air, you cannot jump over again to further increase your elevation from the ground.

So, what is this force and where from does it come? And a force must it be because nothing can start moving from rest without the action of a net force (Newton's first law). Furthermore, it must be a z-mode force as the motion is in z-mode. None of the known z-mode forces are around, visibly or invisibly, directly or indirectly. So we are faced with a bizarre situation: we have here, an entity that manifests itself in reality without actually existing!

Another one of those..... (you know what!)

13.05 Myths and Ghosts: (5) Orbital Motion: The "Zeus" Ghost of all Ghosts

As you know the entire universe is made of atoms of one element or the other. All atoms have a distinct, non-zero number of electrons, all of whom orbit around the nuclei in elliptic or near-circular orbits. We also have a large number of so-called *solar* systems up in the skies where-in, a number of planets orbit around their respective suns in elliptic or near-circular orbits. Without these orbital motions, there will be no atoms and no *materials and substances*, and no universe. It turns out that the orbital motion is the root cause of the existence of the universe (macroscopically and microscopically).

Introducing the "Ellipse"

Attach a stiff sheet of paper to a cardboard and mark out two points, say 10 cm apart, somewhere in the central part of the sheet. Let these points be called *A* and *B*. Push a suitable poster pin, at each of these two locations. Take a sufficiently strong cord, about 20 cm long and tie its two ends (one each) to the two pins. The cord will make a loop. Now place a pencil in the loop and pull it outward to make the cord taut. The cord will get divided into two straight-line segments, joined at the tip of the pencil (point *d*). Keeping the cord taut, now move the pencil around, carefully, keeping it in a vertical position and making sure the cord stays taut. The end-result will be the dotted contour, known as *ellipse*. The point marked *o*, is the mid-point of length *AB*.

The most characteristic feature is that the sum of the two distances of *any* point (on the ellipse), from points A and B , is constant. It must equal the length of the cord that we tied to the pins. Let this length be $2l$. Let the distances of points p_1, p_2, p_3, \dots on the ellipse from pin A be a_1, a_2, a_3, \dots and that from pin B be b_1, b_2, b_3, \dots . Then:

$$(a_1 + b_1) = (a_2 + b_2) = (a_3 + b_3) = 2l \quad \dots\dots(1)$$

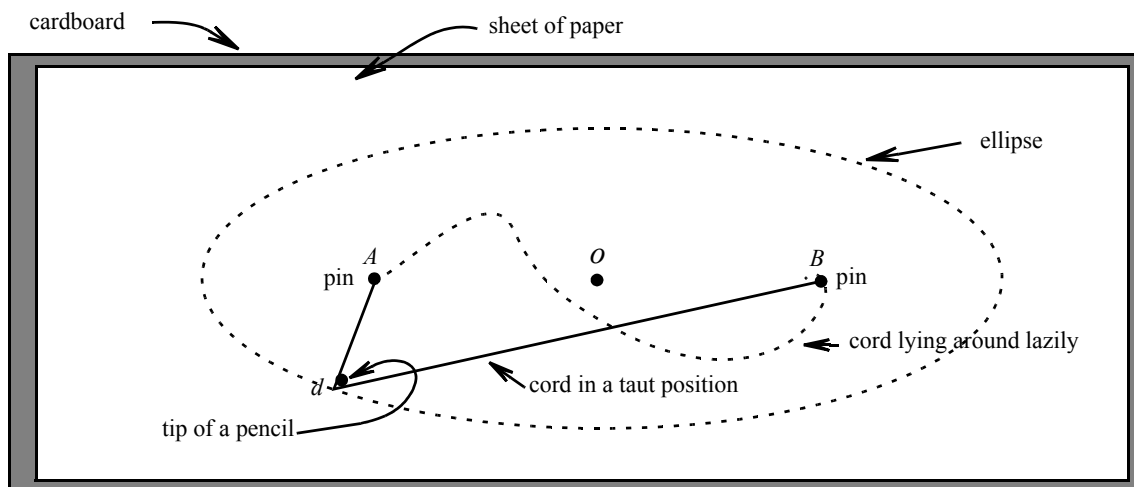


Fig (1) Defining an Ellipse

Doing More

We *lift* the ellipse off, from the above sheet of paper and paste it on another paper. Then we place a set of coordinate axes at the central point of the ellipse, the point o .

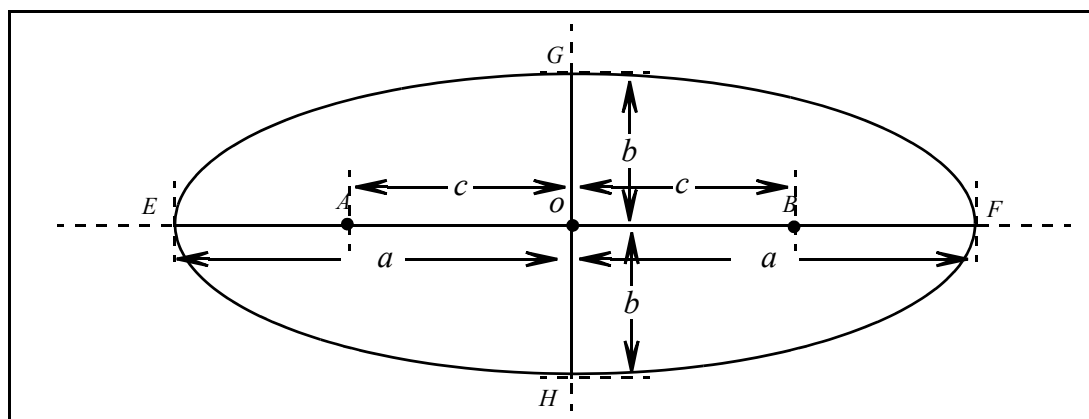


Fig (2) Doing More

(1) Let the points A and B , each be called a *focus* of the ellipse. The ellipse, thus, will have two *foci*.

(2) Let the length EF be called the *major axis* of the ellipse. Then the lengths oE and oF will each be a *semi major axis* of the ellipse. Let $oE = oF = a$. The *major axis* $EF = 2a$

(3) Let the length GH be called the *minor axis* of the ellipse. Then the lengths oG and oH will each be *semi minor axis* of the ellipse. Let $oG = oH = b$. The *minor axis* $GH = 2b$

(4) Let $oA = oB = c$. Then length $AB = 2c$

(5) Area of the ellipse is: πab

(6) Define *eccentricity* ε as the ratio of the intra-foci distance ($2c$) to the major axis ($2a$). Thus

$$\varepsilon = \frac{2c}{2a} = \frac{c}{a} \quad \dots\dots\dots(2)$$

Eccentricity is a measure of how *fat* or how *slim* an ellipse is. Small eccentricity will lead to a circle-like figure and larger eccentricity will cause the ellipse to assume an oval shape.

It is obvious that the ellipse is symmetrical about the two axes and the two foci occur symmetrically about the central point o . The magnitude of c , on the left side, must equal its magnitude on the right side. If the foci are brought closer together, then c on both sides of o , will shrink by identical amounts. Likewise, if the two foci are drawn farther apart, the two c 's will each increase by identical amounts.

If the two foci are brought so close together that c becomes zero, then the eccentricity ε will also become zero. The two foci will essentially merge into one another and there will be only one focus. The ellipse in this case, will reduce to a *circle*, with the focus becoming the *center* of the circle.

Ellipse and Mathematics

From the mathematical point of view, space is a continuum of dimensionless points. Consider a plane in this continuum. We pick two points A and B some distance $2c$ apart, in this plane. Then we flag all points, on this plane, the sum of whose distances from A and B equals $2l = 2a$. The locus of all these flagged points is the ellipse. It can have any desired eccentricity and may adopt different shapes, such as a circle, an ellipse, a parabola or a hyperbola. The general name of these loci is *conic section*. Conic sections offer a lot of useful investigative and practice grounds for students and scholars.

Ellipse and Physics

In physics, we always have an object, the target-object. The target-object will follow an elliptic trajectory in this case. The trajectory will have a major axis of length $2a$, a minor axis of length $2b$. For reasons to be specified later, we are renaming focus B as the *ghost center* and focus A as the *unghost center*. The distance apart of the ghost and the unghost centers is $2c$. All other definitions and characteristics remain unchanged.

As the trajectory (ellipse) of the target-object is not a straight line, the target-object must be subjected to an unbalanced net force, F_{net} , as mandated by Newton's first law. To this end, we need a source-object. The source-object must be placed inside the trajectory and the force (F_{net}) must be directed from the target-object toward the source-object, so that the target object is continually being pulled toward the source object. Such a force is called a central force. We have two centers in our ellipse and we must choose one of these as the home for our source-object. Because the source-object is a real physical object, we place it at the unghost center A . All mandated conditions are thereby satisfied and the target object is ready to be launched. It is expected to keep going in an elliptic trajectory

Keep going in the elliptic trajectory? But we haven't set-up the trajectory yet! There is no ellipse at this time!

The target object must compute its own path given the criterion that if the next point on the trajectory of the target object is to be (say) one centimeter farther away from the unghost-center, then it must be one centimeter closer to the ghost center. If the next point on the trajectory is to be 50 meter away from the unghost center, then it must be 50 meter

closer to the ghost-center. If the next point on the trajectory, is to be half-million meter away from the unghost-center then it must be half-million meter closer to the ghost-center. *and vice versa!* The central force (which has absolutely nothing to do with the ghost-center) does the rest and the elliptic path is chartered. Unless we admit a full knowledge of the ghost-center B , we cannot make any computations of future position(s) on the trajectory and the trajectory will be in complete disarray.

See, how the situation differs from that in mathematics?

So we need the ghost-center B . But what is it and where is it? Well, quite like the ghostly center-of-mass of solid object, the ghost-center B is a dimensionless geometrical point whose location can be worked out from the symmetry of the trajectory. But unlike the center-of-mass point that carries all the mass of the object (on its shoulders, that are not there), this ghostly point does not carry anything. Thus B is a totally mysterious non-entity that escapes all five of our senses plus any psychological, philosophical, terrestrial, geographical, agricultural, economical, chemical, biological, emotional sense or non-sense, that your mind may come up with.

For the center-of-mass, Catherine Cole said: Nothing is there and everything is there

For the ghost-center we are led to believe: Nothing is there and nothing is there

The ghost-center is a complete void, devoid of any recognizability in any shape or form, and a totally incomprehensibly vague nonentity

We must emphasize that in the absence of this ghost center, there will be no solar systems anywhere in the skies, no atoms, no elements and no materials-and-substances. In other words, we speak of complete annihilation of the universe.

The Ghost Center is the Zeus God of mythology in physics

13.05 *Myths and Ghosts: (6) The Everyday Myths*

“Ignore air resistance”.

“Let the cord (or rope or chain or the bungee cord) be massless”

“Let the surface of the table (or of some other object) be frictionless”

“Let the pulley be massless and frictionless”

Such everyday, innocent-looking, assumptions lead us to another variety of ghosts. Ghosts comprising of things that are right there, physically present, in front of our very eyes but we do not see them. We can only see the things that have mass and if an object has no mass (sound waves, for example), we are inherently incapable of seeing it. Converse must also be true.

As an example, consider the mass M , lying on the surface of a table. let it be pulled to the right, with the help of a suspended mass m , a cord and a pulley (as shown in Fig 3a). The system will acquire an acceleration a .

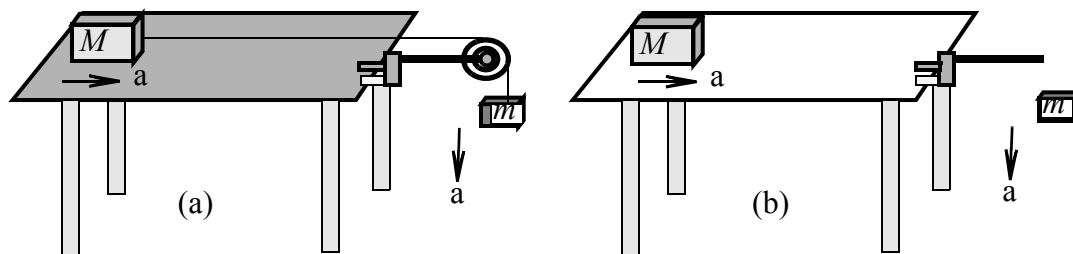


Fig (3) *Implementing the Assumptions*

While you are analyzing the situation, the instructor tells you to ignore air resistance and friction, and to assume that the cord is massless and that the pulley is massless and frictionless. In other words, you are given a pair of magical glasses to wear that masks out all the massless objects and makes the surface of the table appear infinitely smooth. You will see things as shown in Fig (3b). Here the mass M is sliding on the table which has an infinitely smooth surface, with an acceleration a . The other mass, m , is found suspended in mid-air. It does not free-fall, but glides down toward the floor with an acceleration identical to that of mass M .

How very ghostly!

And the above is not an isolated case. There are hundreds of thousands of problems in our textbooks where one or more of the above assumptions are used. So we use this kind of mythology or ghostliness on a regular basis in our everyday problem-solving expeditions. If you draw a diagram for those problems (like Fig 3b), you will be convinced of the nonsensicality of the situation and will become a true believer of the myths we endure in our everyday physical world.