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Perspective

Qualitative and Quantitative Observations about Newton's Third Law of Motion

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Abstract

Newton had given third law of motion in the Principia (1686) at page no 19-20 without mathematical equations, this hard fact is accepted by Edward Cohen [1,2]. Now it is globally taught from the school level that ball rebounds upward obeying third law of Motion. But it is qualitative observation. This aspect needs to be confirmed quantitatively. The qualitative explanation is philosophical but quantitative one is scientific. This aspect is discussed here about conducting experiments.

Part I Using Spherical Bodies

Qualitatively we teach in High School Physics, the ball rebounds after striking the floor or ground; obeying Newton's third law of motion

Action = -Reaction (1)

The force exerted by one body (Action) = - Force exerted by the second body (Reaction) (1)

Newton expressed Action and Reaction in terms of force (push or pull). Eq. (1) is applicable universally, as definition of the law puts no constrains on its applicability.

Freely falling bodies

The simplest example for quantitative study

Let ball freely falls from height of 1m from point A.

Action = Force = weight = mg

Floor exerts force on the ball; then due to mutual interactions of ball and floor reaction arises (action and reaction exist in pairs), and the ball rebounds upward obeying Newton's third law of motion.

Thus, reaction would be mg (equal to action), but exactly opposite in direction i.e., upward direction.

The reaction will be equal to action if ball rebounds to original height (1m), re-tracing exactly its original path. Only then eq. (1).

The action and reaction can be calibrated in terms of distances travelled.

Aim: To quantitatively confirm above qualitative observation

The above observation is taught all over the world, but qualitatively. According to Newton's law if body falls from height of 1m, it must rebound to the height of 1m re-tracing its original path. Thus, aim of discussion, is to quantitatively confirm the above qualitative observations. The qualitative interpretation is philosophical but quantitative one is scientific.

Part II Fabrication

Equipment to be fabricated

Spherical Balls (rubber or plastic or suitable materials). In 1960s and 1970s superballs and skyballs (extremely bouncy balls) are discovered these can also be used purposely. The mass of balls be 0.5 kg or 1kg say, or even different.

As the experiments are supposed to be performed in closed room of air density (1.23kg/m^3) at STP, so the heavier spherical balls would be suitable as effects of air (mainly upthrust, VD_{ball} g) would be insignificant for such heavy balls. These effects would be same for falling and rebounding bodies.

The bodies may be allowed to fall from a suitable platform, without effect of any external force.

Floors or surfaces or thick mat

The balls strike this surface, due to interactions of ball and floor, the reaction arises and body rebounds.

The floors may be 3mx3m in length and breadth or may be fitting size of room. The thickness of the floor may be 0.5 m, for uniform interaction of spherical ball and floor.

Important

The spherical balls and floors must be specifically fabricated to suit the requirements.

These may be get fabricated in various manufacturing units of rubber /plastic materials. Apparently it is the most tedious process in the experiments.

The fabrication of suitable balls and floors mat would only be time consuming; author would take care of everything in this regard. If this stage is successfully passed, then experiments may be conducted in routine manner.

The basic point is we need to choose the suitable materials as surface or thick mat as even now superballs and skyballs are available. The bouncy material of superball may be chosen for thick mat or floor, for another set of observations.

Closed room

The falling and rebounding bodies must not be affected by air currents. So, the external effects must be minimized, it may be done by creating a separate chamber within the room to avoid unnecessary disturbances due to air currents and their effects.

At initial stages such careful observations may be taken, even if effect of air exists, then it would be same for falling and rebounding bodies. The vacuum pump may be used to remove the undesired air.

To negate such effects balls of mass nearly 1kg must be used, the density of air STP is 1.22 kg/m^3

Vacuum chambers may be formed but it would be extremely expensive and may be used in very-2 advanced stage of experiments.

Measurement of rebounding heights of balls with The Hawk-Eye

It is the most technological aspect of the experiments

Hawk-Eye is a computer vision system used in numerous sports such as cricket, tennis, Gaelic football, badminton, hurling, rugby union, association football and volleyball, to visually track the trajectory of the ball and display a profile of its statistically most likely path as a moving image [3]. The onscreen representation of the trajectory results is called Shot Spot.

Once all other equipment are arranged then for initial stage experiments it (The Hawk-Eye) can be even borrowed from other institutions.

It is just possible such instruments are used in ISRO, DRDO, HAL etc. for experimentation at various stages of drones, spacecrafts, aircrafts etc. These may be available in various other aeronautical laboratories or even automobiles laboratories involving advanced research.

Part III Bodies of different shapes

In this case bodies of **various shapes** e.g.**,** semi-spherical, umbrella-shaped, triangular, square, hexagonal, polygon, cone, long, thin pipe, flat, irregular or any feasible typical shape, orientations (angle of fall), etc.

Then experiments can be conducted identically. Initially bodies of same mass (say, 1kg) same material but of different composition must be chosen.

Also there are different bodies of different types and characteristics.

Various bodies: wool, wood, cloth, spring, steel, rubber, clay, kneaded flour, chewing gum, sponge, typical plastic, porous material, air/fluid filled artifact, super ball, sky ball, or any other typical body,

Characteristics of bodies

Inherent composition, nature, flexibility, elasticity, plasticity, rigidity, magnitude, size, the distinctiveness of interacting bodies or mode of interactions of bodies, unsymmetrical distribution of mass in the body, and other relevant factors like surfaces on which bodies interact [1-3].

Thus these simple experiments numerous experiments are possible in view of eqs.(2-4)

Part IV Speculative Outcome of experiments

Reaction = -Q Action (2)

$Q = Q_{shape} \times Q_{composition} \times Q_{target} \times Q_{other}$ (3)

Reaction = -Action ($Q_{shap} \times Q_{compositior} \times Q_{target} \times Q_{other}$) (4)

The values of Q_i's can be determined experiments in the outline of experiments discussed above.

So numerous experiments are possible, only simplest one's are discussed as above.

Bibliography

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