NASA's Free Fall Experiments in View of Newton's Principia

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***Abstract*:- In *the Principia* in general scholium after proposition XLII (pp.388) and proposition X (p.231) of Book III, Newton maintained that all bodies must fall with equal or constant velocity (1m/s , say) or zero acceleration in vacuum. But practically all bodies fall with constant acceleration (variable velocity) in vacuum. In the world's biggest vacuum chamber (NASA's Space Power Facility, Ohio), a feather and bowling ball has been observe to touch ground at same. Similarly in Apollo 15 mission, astronauts (August 1971) dropped a feather and hammers on the surface of moon both reached at same time. These are the rarest experiments but technical details of experiments have not been given. These experiments justify that all bodies fall with equal acceleration (like Galileo's demonstration) but in both cases, different distances travelled in different time have not been recorded as required in Table I. The values of accelerations due to gravity on earth and moon are g_e=9.8m/s^2 and g_m=1.62m/s^2 . Thus such experiments may be repeated to measure different distances travelled in different time specifically. Likewise in Book III of the Principia , the Propositions I-X illustrate law of gravitation; these quote inverse square law number of times but gravitational force is not expressed as product of mass of bodies. Thus still various aspects of experiments (NASA's free fall and Apollo 15 mission) and the Principia can be critically discussed.**

Key Words : Apollo 15 experiments, Moon , Evacuated Chamber, Galieo , Newton , Principia

1.0 INTRODUCTION

Aristotle demonstrated in air a stone falls quickly than straw [1]. Galileo[2] is believed to have demonstrated from the Leaning Tower of Pisa (height equal to 18 stories) that one pound shot and ten pound shots strike bottom at same time. Newton's perception in the Principia [3] Book III in general scholium after Proposition XLII (pp. 388) and Proposition X (pp.231) is that feather and gold descend with equal velocity (zero acceleration). These observations have been taken with naked eye.

In NASA's vacuum chamber (biggest in the world) at Space Power Facility Ohio [4] it was observed that feather and bowling ball strike the bottom at same instant. Further David Scot of Apollo 15 mission at moon observed that a hammer and feather appear to fall at bottom at same time (constant acceleration). Such experiments can be repeated with spheres of mass 1mg and 1000kg. In general our main aim is to experimentally confirm relating acceleration due to gravity (g) with time and distance i.e. eq.(1) , on the surfaces of earth (g_e =9.8m/s^2) and moon (g_m=1.62m/s^2). The next part of experiments is to check the various distances corresponding to times as shown in Table I on the basis of eq.(1). These experiments are due at other heavenly bodies as astronauts perform other experiments. Due to external influences the state of microgravity can be produced in laboratories bur for few seconds. These observations have been critically analyzed in view of Newton's original quotes in the Principia (General Scholium page 388 and Proposition X, page 231), that bodies descend with equal velocity.

General Scholium , Principia Book III (pp.388) Newton's Principia (Book III) at page 388 states as [3] "Bodies projected in our air suffer no resistance but from the air. Withdraw the air, as is done in Mr. Boyle's vacuum, and the resistance ceases; for in this void a bit of fine down and a piece of solid gold descend with equal velocity." Similarly the Proposition X of the Book III of the Principia quote the same .

2.0 INTERPRETATION NEWTON'S PERCEPTION THAT BODIES FALL WITH ZERO ACCELERATION.

Newton maintained that 'a bit of fine down / first plumage of many young birds (40kg/m^3, say)' and 'a piece of solid gold (19,300kg/m^3)' i.e. all bodies **(lighter or heavier) descend with equal velocity** (1m/s, say) or **constant velocity** or **zero acceleration** due to gravity in vacuum [3]. However on the earth bodies are observed to fall with constant acceleration 9.8m/s^2 , and value of acceleration due to Moon's gravity is 1.62m/s^2 . Newton specifically mentioned that a bit of fine down/feather i.e. the lightest material and gold (heaviest material) known at that time, fall with equal velocity (1m/s, say) in vacuum due to gravity can be analyzed [5]. In accelerated motion velocity of body added by 9.8m/s in every second (9.8m/s , 19.6m/s,29.4m/s etc.etc.) ; as bodies fall with constant acceleration 9.8m/s^2 in vacuum due to gravity. At the moon (g_m=1.62m/s^2), the velocity of body is added 1.62m/s every second (1.62m/s,3.34m/s,6.48m/s etc.etc.). The through which bodies fall will be six times smaller on moon than on earth due to lesser value of g on the surface of moon.

As bodies fall with equal acceleration [1], then travel equal distances (S) in equal intervals of time (t) as

$S = \frac{1}{2} gt^2$ or $t = \sqrt{\frac{2S}{g}}$ (1)

Then body will travel distances 4.9m, 19.6m, 44.1m and 78.4m after 1s, 2s,3s and 4s respectively ($g = 9.8m/s^2$). At surface on moon body will travel 0.81m, 3.24s, 7.29m after 1s, 2s, 3s and 4s etc.etc. The velocity of body at final point (v) at time t is given by[1]

$v=gt$ (2),

Further acceleration due to gravity on earth is given by

$G =gR^2 /M$ or $g =GM/R^2$ (3)

where R is distance between centers, of body and earth, M is mass of the earth. Consequently it would mean theoretical possibility of variation in considerable scientific and celestial data. The celestial data would remain the same whether g_e or g_m is used. The acceleration due to gravity g was measured equal to 9.80665 m/s^2 in 1888 [6]. Newton did not give any reason that why body falls with equal or constant velocity but constant acceleration of bodies is given by eq.(3)

Newton initiated physics as subject separating it from natural philosophy but did not end it. In this case as already mentioned, Newton's explanation appears to be philosophical and qualitative rather than quantitative. In the In Book I of the Principia [7] Newton did not define acceleration as we understand neither on new definitions nor existing terms (pp.1-9). Even word acceleration was not mentioned in second law of motion, also the equation F =ma was not given in the explanation (pp.19) . It is evident from the critical analysis of literature that equation F =ma was stated by Leonhard Euler [8] in 1775 i.e. 48 years after death of Newton.

3.0 NASA'S EXPERIMENTS CONFIRMING THAT BODIES APPEAR TO FALL WITH CONSTANT ACCELERATION.

The world's largest vacuum chamber exists in NASA Space Power Facility in Ohio . It has height *30.5 meters* and breadth *37.2 meters* was utilized to re-confirm Galileo's demonstration. The video illustrates that a bunch of 4-5 feathers (unsymmetrical) and bowling ball reached bottom at the same time. Further such fundamental experiments may be scientifically conducted by dropping spherical body of mass 1mg or less and 1000kg or more of various bodies. The most significant aspect is to measure times corresponding to various distances from reference point.

Experiments conducted in Apollo 15 mission

Apollo 15 (the ninth crewed mission in the United States' Apollo program), commander David Scott dropped a hammer and feather (asymmetrical bodies) on the surface of moon, both appeared to fall down in the same time.

But again, the distances travelled by bodies corresponding to time has not been mentioned.

4.0 COMPARISON AND ANALYSIS OF EXPERIMENTS ON MOON IN VACUUM CHAMBER.

On the surface of moon it appears that feather and hammer may have fallen from height of 2m, whereas the feather and bowling ball through 30 meters as appears from the videos (estimates only) . The exact experiments have been conducted specifically to draw quantitative conclusions. Then the distances descended on the surface of moon ($S=1/2g\ t^2$) would be six times smaller than that on the earth .

So if these experiments are conducted on the earth and moon, then quantitative conclusions can be drawn. Such experiments (on earth and moon) are absolutely necessary for quantitative confirmation of equations.

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