CONCEPT OF EQUILIBRIUM AND ROTATIONAL INERTIA

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En Pointe is a position in ballet that is presented on the tips of the toes. ***En Pointe*** can be of different varieties in ballet, but their specific focus is based on grace and particular technique. The structural concept behind the technique of ***En Pointe*** is that of ***equilibrium***. A body or physical system when having no movement or when being in unaccelerated motion in which the resultant of all forces acting on it is zero and the sum of all torques about any axis is zero is known as ***equilibrium.***

Fig 1

"Equilibrium is a condition in which all acting influences are canceled by others, resulting in a stable, balanced, or unchanging system."

The dancer is at position of En Pointe.

The weight of the dancer that is acting downwards is balanced by the normal force that is acting from the ground upwards and the friction from the ground that is acting sideways. The downward push of the weight of the dancer and the floor's upward push go through the centre of gravity of the ballet dancer balancing and as a result there is no total force or torque. The centre of gravity is the point at which the whole object will balance.

NET TORQUE= 0

NET FORCE=0

WEIGHT OF DANCER=NORMAL FORCE FROM THE FLOOR.

The dancer is balanced at the ***En Pointe*** position due to the fact that her centre of gravity is directly above the area of contact with the floor. It is a very hard position at which to be balanced as the area of contact is very small. The smaller the area the more difficult is for the dancer to balance herself

Fig 2

Another technique in ballet that uses structural concept is called ***Pirouette. Pirouette*** is defined as the full turn of the body on the point of the toe. It is a controlled turn on one leg that returns to the starting position or finish position. The structural concept that a ***Pirouette*** uses is that of **angular velocity, rotational inertia and angular momentum.** Angular velocity is the rate at which an object spins. Rotational inertia is the inertia (the tendency of the body to resist acceleration) of a rotating structure and angular momentum is the product of rotational inertia and angular velocity.

The ballerina is ready to perform a Pirouette spin. Her rotational inertia applies a resistance to spinning. It indicates how difficult it is to start an object to spin. Rotational inertia depends on the mass of the ballerina. It is directly proportional to the mass of the dancer. It depends on how far away the mass of the object is placed from the rotational axis. The angular momentum depends on the torque. When there is no torque applied there is no angular momentum. Due to the fact that angular momentum is the product of rotational inertia and angular velocity, the greater the rotational inertia the smaller the angular velocity.

Fig 3

As the dancer extends her arms to perform the ***Pirouette*** the radius R is large as a result the rotational inertia increases being responsible for a small angular velocity. It will be more difficult for the ballerina to perform the ***Pirouette*** as she will not rotate as easy as she would with her arms brought together.

Newton first law of motion states for circular motion when an object is rotating about an axis it will continue rotating along that axis. $\mathbf{I=mR^2}$ where I=Rotational inertia, m=mass of rotating object R=radius.

As the ballerina is ready to perform her ***Pirouette*** with her arms brought together the radius R is small and thus the rotational inertia is small as well, leading to a large angular velocity. As the ballerina pushes the floor to one direction the friction between the leg and the floor develops a push the opposite way.

Fig4

Rotational inertia is directly linked to the mass of an object. It is proportional to the mass of the object and to the square of the distance from the rotational axis to the objects edge. In order to rotate faster the rotational inertia must decreases this can be achieved in 2 ways by decreasing the mass and by making sure that the body is very close to the rotational axis. Most dancers prefer both ending up with dramatic weight loss.