

## Physics Integration Lesson 9 – More Than the Sum of the Parts

S. Gollmer (2020)

Up to this point in our study of physics we have treated every object of interest as a point in space acted on by forces, which result in acceleration, change in velocity and change in position. To simplify calculations, the concepts of work and energy conservation were introduced. However, what happens when objects are treated as they really are, a collection of objects that interact with each other?

Defined as the product of mass and velocity, momentum provides a concept that is most helpful when describing two interacting objects. Newton's 3<sup>rd</sup> law states "for every action there is an equal and opposite reaction." Therefore, when two objects interact, their total momentum is unchanged. Known as conservation of momentum, this principle explains the recoil experienced when firing a gun and allows final velocities to be calculated during collisions and explosions. It is also essential when designing rockets that can travel to distant planets.

What is most intriguing is that once two or more objects interact, a fundamentally new property of the material world emerges, rotation. Point particles cannot rotate apart from an external force. But this begs the question as to the source of the external force, a second object. Rotation adds an additional dimension to everything studied thus far. To every physical quantity there is a rotational equivalent: force/torque; mass/moment of inertia; and angular forms of velocity, momentum and energy.

Once two or more particles are present, it is possible to describe their complex interaction through forces inherent to the objects: masses interact through gravity and charges interact through electric fields. Treating these particles as self-interacting, it is possible to model physical phenomena from the atomic to galactic scale. The beauty of the universe's design is that each physical scale acts mostly independent of the other scales. Nuclear physics act independent of the laws of chemistry. Although dependent on chemistry and physics; biology, meteorology, geology and astronomy can be treated as independent disciplines of study.

1. Rotation is evidence that an object is more than a collection of its parts. Individual particles have no rotation, but when acting together they do. Can this argument be used to explain life as a collection of complex interactions? Explain.
2. The ability to separate physical activity at the atomic scale from that at the molecule scale, organism scale, planetary scale and the galactic scale is seen as a design feature. Is there a feature of the world in which you live, that you feel speaks loudly to the existence of design? Explain.