Physics of a bow and arrow

The longbow has been used over the years, first as a weapon to hunt, later as a war weapon, and now its used as a sport, but its physics had always been the same over the years, regardless of its use. This physics involves two components: bow mechanics and arrow flightBow mechanics: when an archer pulls back the string, he does work on the bow, and is converted to potential energy. Upon release of the arrow, this potential energy is converted into kinetic energy, most of which is transferred to the arrow and gives it its initial velocity.

The force that the archer applies to the bow to bend it is actually the weight that he feels on his fingers as he pulls back the string. The archer feels a greater weight on his fingers as he pulls the string farther away from its resting position. The limb of the bow acts like a complicated spring. As the string is pulled back, the shape of the limb changes as does the spring force it exerts. This spring force is labeled S in the adjacent diagram.

Thus, the tension, T, in the string is S*cos(B)The area under a straight-line curve, F*d/2, is the amount of energy stored in the bow. There are several types of straight bows; the most common ones are the longbow and the short bow. The main difference, and the reason on which the longbow was used more and is more effective is that because of the size of it, the longbow can store more energy and by consequence, have a larger range than the short bow, but it does need more force to operate it.

The range of the arrow depends on the following: Its initial velocity and angle of departure, the amount of air resistance and wind effects, and the weight of the arrow. The potential energy stored on the bow is converted to kinetic energy as the archer lets go off the string, and this energy gives the arrow its initial velocity. When the arrow leaves the bow, both it (the arrow) and the bow move. Thus, the total kinetic energy is the sum of the kinetic energies of both the arrow and the bow.

The kinetic energy of the arrow is ? *m*v^2, where m is the mass of the arrow and v is its initial velocity. The kinetic energy of the bow is ? *k*M*v^2, where M is the mass of the bow and k is the sum of the kinetic energies of the different parts of the bow. The constant k has to be taken into account since the velocity of a specific part of the bow is proportional to the velocity of the arrow. The total kinetic energy of the system is equal to its total potential energy.

Thus, ? *e*F*d = ? *m*v^2 + ? *k*M*v^2. The initial velocity of the arrow is: (e*F*d/(m + k*M))^(-2). Due to the absence of air resistance, the arrow undergoes projectile motion and travels in a parabolic trajectory. When air resistance is present, a drag force acts on the arrow to slow it down by transferring momentum from the arrow to the air. Two types of drag forces act on an arrow during its flight: shear drag and form drag.

Shear drag: As the arrow flies through the air, it drags the adjacent air alongThis air drags the air around it as well, creating layers of air with different velocities along the arrowThis causes frictionThe shear drag is proportional to the velocity of the air and can be described by the equation, F = c*u, where c is a constant and u is the velocity of the arrowForm drag: As the arrow flies through the air, the shear drag creates eddies behind itThese eddies drop off the arrow to form a turbulent wake, resulting in form dragAs the arrow flies faster, it creates a greater turbulence and thus - a greater form dragThe form drag is proportional to the square of the arrow? s velocity and can be described by the equation, F = c*u^2The form drag acts at right angles to the arrowThe form drag pushing on the arrow generates a torque given by: Torque = Form Drag * (a + b)This results in the arrow experiencing frequent oscillations during its flightLike bows, arrow shafts can be made out of wood, aluminum and fiberglass as well as carbon, all of which are light materialsThe fletching can be made out of either feathers or plastic