The Physics Of A Yo Essay, Research Paper

The Physics of a Yo-yo

In everything that we do, there is some aspect of physics involved in it.

Even if we are just standing still on the ground, or leaning up against a wall,

there are still numerous forces acting upon us. This paper will tell of the

physics involved in throwing a yo-yo.

When you release a yo-yo, gravity acts on its center of mass to pull the

yo-yo downward. Because the string of the yo-yo is wrapped around the yo-yo’s

axle, and because one end of the string is attached to your finger, the yo-yo is

forced to rotate as it drops. If the yo-yo could not rotate, it would not drop.

Just as any object falling in a gravitational field, the rate of drop

increases with time (it decreases 9.8 meters every second to be exact) and so,

necessarily, does the rotation rate of the yo-yo. The rate of drop and the

rotation rate are greatest when the bottom is reached and the string is

completely unwound. The spinning yo-yo contains rotational kinetic energy taken

from the gravitation potential energy through which the yo-yo has dropped.

Usually, the string is tied loosely around the axle so that the yo-yo can

continue to spin at the bottom. Because the full length of the string has been

laid out, the yo-yo can drop no further and, consequently, the rotation rate

cannot increase further. If left in this condition, the friction between the

axle and the string will eventually dissipate the energy

Wallin, 2

of rotation or, equivalently, the rotational kinetic energy of the yo-yo and

the yo-yo will come to rest.

However, a momentary tug on the string causes the friction between the string

and the axle briefly to increase so that the axle no longer slips within the

string. When the axle stops slipping, the rotational kinetic energy of the

spinning yo-yo is large enough to cause the string to wind around the axle. This

causes the yo-yo to begin to "climb" back up the string. After the

first one or two rotations, the string can no longer slip, so the process of

climbing up the string continues beyond the momentary application of the tug.

As the yo-yo continues to climb back up the string, the angular momentum

(rotational kinetic energy) of the yo-yo is converted back into gravitational

potential corresponding to the increasing height of the center of mass of the

yo-yo. For this reason, the yo-yo’s rotational kinetic energy and, hence, its

rotation rate, steadily decreases as the yo-yo rises. This is, of course, the

reverse of the process when the yo-yo was dropped.

If not for frictional losses, the yo-yo would climb all the way back up the

string to your hand just as its rotational rate decreases to zero. But, due to

friction, the yo-yo does not quite make it all the way back up to your hand

before it stops rotating.

Thereafter, the process repeats, with the yo-yo returning short of its

previous height on each cycle. Eventually, the yo-yo comes to rest at the

bottom.

Of course, as everyone knows, it is possible to keep the yo-yo going

indefinitely by giving it a slight upward pull on each cycle. This pull can be

combined with the tug required to initiate the climb back up the string. The

pull serves to give the center of mass of the yo-yo a little extra kinetic

energy to compensate for frictional losses, so that the

Wallin, 3

yo-yo can be kept going indefinitely.

Yo-yos can also be thrown horizontally, or launched in other directions. The

principle of operation is then just the same except that the kinetic energy of

the center of mass, which is converted into spin as the string unwinds, results

from being thrown, rather than from falling through a gravitational potential.