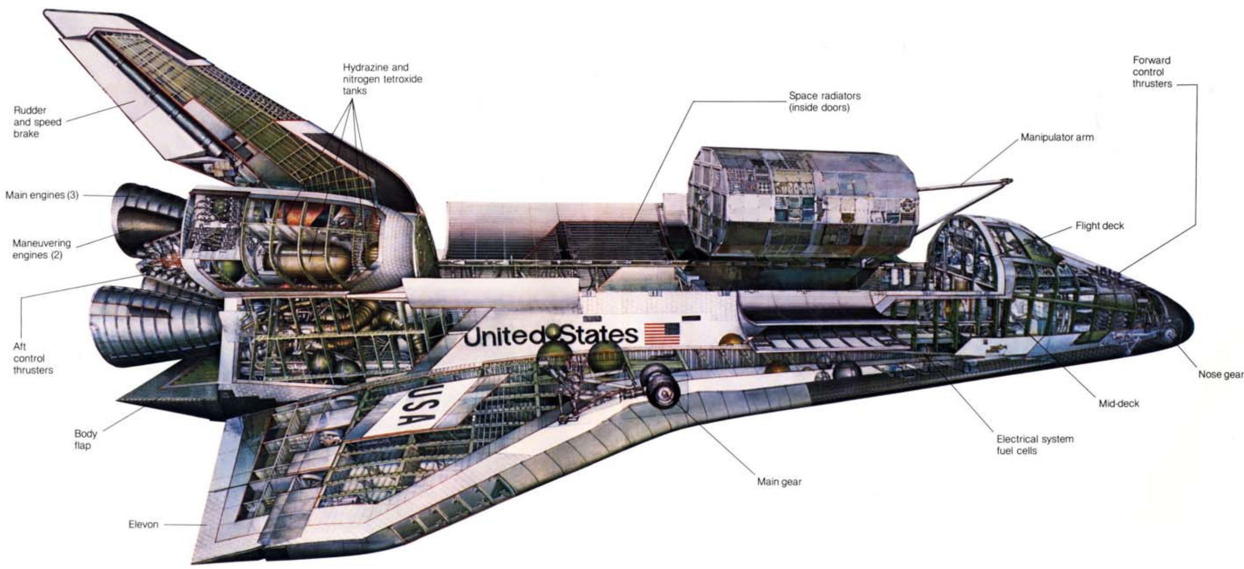
Physics Honors
Quiz 2.1 Version E – Energy Conservation

Name: **KEY**
Period:

1. The final Space Shuttle flight is coming soon, marking the end of one era in space travel and – hopefully – the beginning of another[1]. A typical Space Shuttle orbit is at an altitude of about 300 km above the Earth (this isn't *that* high up – the diameter of the Earth is 12,756 km). At that height, the acceleration due to gravity is slightly (5%) less than on the surface of the Earth: 9.36 m/s^2 instead of 9.81 m/s^2. In order to maintain such a low orbit, the Space Shuttle must cruise with a speed of about 7725 m/s. The orbiter's mass varies depending on what it is carrying, but is typically around 80,000 kg.



a. Calculate the kinetic energy, gravitational potential energy, and total mechanical energy of the Space Shuttle in flight.

$K = ½mv^2 = ½(80{,}000\text{ kg})(7725\text{ m/s})^2 = 2.39\times10^{12}\text{ J}$

$U = mgh = (80{,}000\text{ kg})(9.36\text{ m/s}^2)(300{,}000\text{ m}) = 2.25\times10^{11}\text{ J}$

$E_{tot} = K + U = 2.62\times10^{12}\text{ J}$

b. When the Space Shuttle lands and rolls to a halt, its total mechanical energy is zero. What happened to the energy you calculated in part (a)? Was it lost? Destroyed? Explain.

Energy is never destroyed, it only changes form. In this case, it ends up heating the air around the Shuttle and the Shuttle itself during landing. This is a dangerous transfer of energy – in fact, it led to the disintegration of the Columbia in February, 2003.

http://en.wikipedia.org/wiki/Space_Shuttle_Columbia_disaster

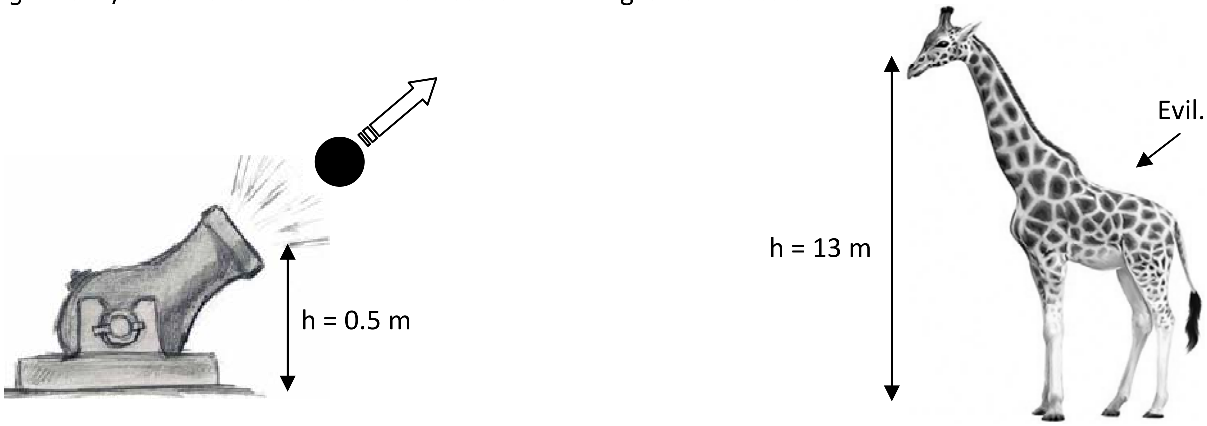
---

[1] http://www.nasa.gov/mission_pages/shuttle/shuttlemissions/index.html

Physics Honors
Quiz 2.1 Version E – Energy Conservation

Name: **KEY**
Period:

2. The cannon below fires heavy (5 kg) cannonballs. Each time the cannon is fired, the explosion within the cannon's chamber gives the cannonball 2,000 J of kinetic energy. For this problem please use g = 10 m/s^2 to make the calculations easier. Drawing is not to scale.



a. What is the speed of the cannonball when it exits the cannon?

Since its kinetic energy (2,000 J) is known, we can set K = ½mv^2 to solve for the speed:

2000 J = ½(5 kg)v^2 ... solve to get v = 28.3 m/s.

b. If the cannon was pointed directly upward, how high up would the cannonball go (measured with respect to the opening of the cannon)?

The cannonball would have 2000 J of kinetic energy to "spend" on gaining potential energy, so:

2000 J = mgh = (5 kg)(10 m/s^2)h ... solve to get h = 40 m.

c. The cannonball hits an evil giraffe in the head. The giraffe's head is at a height of 13 m above the ground. At what speed does the cannonball hit the giraffe? Include in your answer a schematic (*i.e.*, not numerically precise) energy bar graph of the type we have drawn in class.

When the cannonball leaves the cannon, it has total energy

E_{tot} = K + U = 2000 J + mgh = 2000 J + (5 kg)(10 m/s^2)(0.5 m) = 2025 J

When the cannonball strikes the Evil Giraffe on the head, it still has exactly this much energy, just a different distribution between kinetic and potential.

E_{tot} = 2025 J = K + U = ½mv^2 + mgh = ½(5 kg)v^2 + (5 kg)(10 m/s^2)(13 m) = 2.5v^2 + 650 J

We can solve this to get v =23.4 m/s. Hits the giraffe kind of hard. Sorry giraffe, but you had it coming.

SCHEMATIC BAR GRAPH ON NEXT PAGE.

Physics Honors
Quiz 2.1 Version E – Energy Conservation

Name: **KEY**
Period: