motion and energy in Automobile Racing

Motion and Energy

Automobile racing involves various forms of energy and various types of motion. Race car engineers and designers are constantly coming up with new innovations to make their cars travel faster and more safely.

Question for Analysis

How do we use the concepts of kinetic energy, work and power to evaluate automobile racing?

Concepts

Acceleration

The rate at which an object's velocity changes; $a = \Delta v / \Delta t$

Aerodynamics

The way the shape of an object affects the flow of air over, around or under it.

Bernoulli's principle

Air moving faster over the longer path on a wing causes a decrease in pressure, resulting in a force in the direction of the decrease in pressure.

Downforce

The aerodynamic force on a car that pushes it downward, resulting in better traction.

Force

Any push or pull.

Kinetic energy

Energy of motion. The formula for kinetic energy is $KE = \frac{1}{2} m v^2$, or ½ the mass times the velocity squared.

Mass

The amount of matter or substance in an object.

Potential energy

Energy due to position, or stored energy.

Power

Rate of doing work, or work divided by time; $P = W / t$

Speed

The distance an object travels divided by the time it takes to travel that distance.

Thermal energy

Heat energy.

Velocity

The speed of an object, including its direction. Velocity = change in distance over time, or $v = \Delta d / \Delta t$

Venturi effect

The effect produced by narrowing a passage of air as the air travels, causing an increase in the speed of the air, a drop in pressure and a force in the direction of the air passage.

Watt

A measurement of power. One watt is 1 joule of work per 1 second. A joule of work is 1 Newton of force acting through 1 meter.

Weight

The force of gravity pulling on an object, or the mass of the object times its acceleration due to gravity.

Work

The force on an object times the distance through which the force moves the object as the work is converted to energy of motion.

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Using the Racing Oral History Interview

View the oral history of Carroll Shelby as he talks about kinetic energy and brakes. Notice that he explains that the car's brakes can turn its kinetic energy of motion into heat energy.

Carroll Shelby: Kinetic Energy and Brakes

Speed, or Velocity, and Acceleration in Auto Racing

The speed of a car is measured by the distance the car covers in a certain amount of time. The formula for speed is s = d / t, or speed equals distance divided by time. A car that travels 100 miles in 2 hours would be traveling 50 miles per hour, since its speed = 100 miles / 2 hours = 50 miles / hour. Or, distance can be calculated by multiplying speed or velocity times time. So if a car is traveling 120 miles / hour, it will travel 360 miles in 3 hours. d=v * t, distance = 120 miles/hour * 3 hours = 360 miles.

Often, speed, or velocity, is measured in meters per second. A car that travels 200 meters in 8 seconds would be traveling 25 meters/second, since speed = 200 meters/8 second = 25 meters/second. If we work in meters per second, we can calculate the distance in meters. A car traveling at 40 meters/second for 10 seconds will travel 400 meters, since distance = 40 meters/second * 10 seconds = 400 meters.

Velocity is technically called displacement/time. Displacement is both distance and direction, while velocity is speed in a particular direction. Often, as in this Background Information Sheet, speed and velocity are used interchangeably.

Kinetic and Potential Energy

Kinetic energy is energy of motion. Kinetic energy is usually measured using meters and seconds. Kinetic energy equals one-half the mass of an object times its velocity squared (KE = ½ m * v^2). A toy car with a mass of 2 kilograms traveling at 10 meters/second will have 100 kilogram-meters^2/second^2, or what we call 100 joules; the unit of energy when measured in kilogram-meters^2/second^2 is the joule. So KE = ½ * 2 kilograms * (10 meters/second)^2 , or ½ * 2 * 10 * 10 = 100 kilogram-meters^2/second^2, or 100 joules.

A race car has a lot of kinetic energy. Look at the picture of the red #9 NASCAR race car [Ford Thunderbird NASCAR Winston Cup Race Car Driven by Bill Elliott, 1987 ID# THF69258]. The mass of this car is about 1,588 kilograms (3,500 pounds). If it travels at 180 miles/hour, or about 80 meters/second, its kinetic energy will be:

KE = ½ m * v^2 = ½ * 1,588 * 80 * 80 = 5,081,600 joules.

Potential energy is the energy due to the position of the object. A rock on the edge of a building's roof has the potential to fall and turn into kinetic energy. Potential energy can also be energy stored chemically, like the energy stored in gasoline.

Thermal energy is energy due to heat, or heat energy. When an automobile engine burns fuel, the potential energy in the fuel is turned into thermal energy – heat – that operates the pistons to change the thermal energy into kinetic energy, or energy of motion. The pistons then move a crankshaft that is attached to the wheels and makes them move.

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Work and Horsepower

The work done by the engine to create kinetic energy to move the car is measured differently than the way we normally think of work. The amount of work that a car engine can produce is measured in horsepower. The concept of horsepower was created by James Watt, who lived from 1736 to 1819. He measured the amount of weight a horse could move a certain distance in a given time and came up with 33,000 foot-pounds/minute, which he called 1 horsepower (1 hp). Thus an engine with 350 horsepower could do the work of 350 horses.

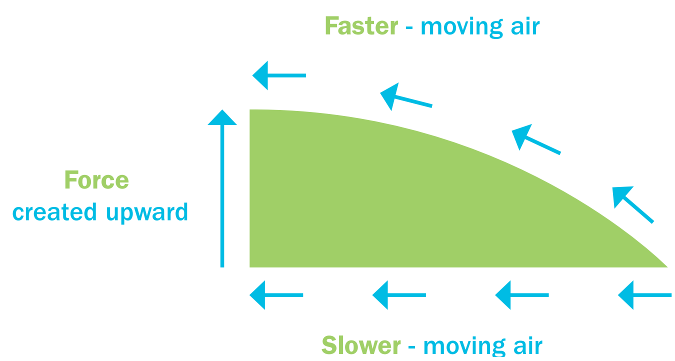
Work is measured by multiplying the amount of force on an object by the distance an object is moved by the force. Work equals force times distance ($W = F * d$). Work is measured in a unit called joules.

Power is a measure of how fast work can be completed. Power is work divided by time ($P = W / t$). Power is measured in watts, and 1 watt is 1 joule per second. One horsepower is equivalent to 746 watts.

Bernoulli's Principle and Energy

One of the most interesting aspects of automobile racing involves Bernoulli's principle. Fast-moving air produces a drop in air pressure and a force in the direction of the drop in pressure. If you look at a wing of an airplane, you will see that the top of the wing has a longer surface than the bottom of the wing (see Fig.1). The air has to travel faster over the longer upper surface. The faster-moving air produces a drop in pressure above the wing, giving the bottom of the wing comparatively higher pressure. There will be a force created from the pressure difference, and that force will push, or lift, the wing upward.

Fig. 1



Airfoils

Race car engineers use Bernoulli's principle to make winglike objects called airfoils. The "wing" of the airfoil is turned upside down so that the longer surface is on the bottom. The airfoil is attached to either the front or the back of the car to push down on it and gain better traction. Look at the airfoil on the Texaco Star race car [March 84C Race Car, 1984 (aerial view ID# THF69371)].

Air resistance can also be used to force a car down. Air hits the front of a race car that has a low front and continues over the top, actually pushing down on the front of the car and giving better traction. Look at the front of the red #9Ford Thunderbird [Ford Thunderbird NASCAR Winston Cup Race Car Driven by Bill Elliott, 1987 (aerial view ID# THF69260)]. Notice that its low front causes the oncoming air to push down on the front of the car.

Designs of race cars are always being improved to allow the cars to travel faster.