

Section 4.4: Forces Applied to Automotive Technology

Section 4.4 Questions, page 183

1. (a) Tire Y is more likely to experience hydroplaning when driving on a wet road. Tire X has deeper treads so water can move through the grooves and pass through tire X more easily. Water in front of the tire Y may not pass through the tire quickly enough, causing the water level in front of the tire to increase. This water build-up in front of the tire can lead to hydroplaning.
- (b) The magnitude of static friction acting on a tire on a road surface depends on the surface area of the tire that is in contact with the road. The greater the surface area, the greater the friction. As the surface area decreases during the transition stage of hydroplaning, the force of friction acting on the tire decreases.
2. Answers may vary. Sample answer:
The wear pattern on the low pressure tire reduces the tread area on the outer edges of the tire. As the tread area decreases, the number of grooves that provide pathways for water to pass through decreases. Hydroplaning will happen more easily. The wear pattern on the excess pressure tire reduces the tread area in the middle of the tire. On a wet road, the water in front of the tire may not pass along the sides of the tire quickly enough, causing hydroplaning.
3. When the driver starts to speed up on a wet road, the water in front of the tire may not have enough time to pass through the grooves toward the back of the tire. This causes the water level in front of the tire to increase. As the speed continues to increase, the water level in front of the tire increases. As the water level builds up, the tire will start to lose contact with the road surface. In this situation, the force of friction acting on the tires will reduce.
4. Answers may vary. Sample answer:
The rim brake on a bicycle uses a lever to squeeze the brake pads against the rim of the wheel to apply a normal force that provides a force of friction on the rim to slow down the wheel, and thus the bicycle. The disc brake on a car works similarly but it is a piston that squeezes the brake pads and the normal force is applied to a rotor with the force of friction acting on the rotor to slow down the wheel, and thus the car.

5. Answers may vary. Sample answers:

(a) By increasing the friction on the bicycle wheel, you can increase the amount of energy you need to exert to pedal the bicycle. The device does this by putting the bicycle in a certain gear.

(b) I would design a series of gear wheels that are engaged by a bicycle chain. A lever on top of the bicycle handle bars would position the chain on the appropriate gear wheel. When the smaller wheel is engaged, resistance is the greatest.

Diagrams may vary. Students should include a diagram that matches the description of the stationary bicycle above.

(c) To determine the relationship between the device setting and maximum force of static friction acting on a bicycle wheel, I would have a person sit on a bicycle set at a particular gear. The person would pedal the bicycle and rate the effort it took to pedal for 1 min. This is repeated for each gear. Comparing the pedalling effort by gear will determine the relationship between the two variables.

6. Answers may vary. Sample answer:

In disc brakes, a piston pushes the brake pads against a rotor. The harder the brake pads are squeezed, the greater is the normal force on the rotor, which in turn increases the force of friction acting on the rotor. According to Newton's second law, as the net force on the rotor decreases due to friction, the acceleration of the rotor (attached to the wheel) decreases. As a result, the motion of the wheel decreases, slowing down the car.

7. Answers may vary. Sample answer:

The statement is true. If there is no friction from the road on the tires, the car continues at the same speed. For example, when a driver tries to break while on ice, the tires can stop completely, but the car will continue to glide. When there is friction between the road and tires, a tire spinning slower decreases the distance the car travels per second.

8. Answers may vary. Sample answers:

(a) An ABS uses a computer to monitor the speed of the wheels of a car. A sudden large decrease in speed may cause a car to skid. In this situation, the computer can change the force on the brake pads rapidly, allowing the car to slow down as fast as possible, reducing the stopping distance without the tires skidding.

(b) The computer of an ABS can detect the speed of the wheels and change the force on the brake pads to adjust the friction on the wheels. This helps the driver steer the car even while applying firm pressure to the brake pedal.

9. Answers may vary. Sample answers:

(a) An ABS and traction control both make use of sensors and computer controls to increase the safety of a car. When a wheel experiences a sudden decrease in speed, the computer of an ABS will quickly reduce the force on the brake pads until the wheel moves at an acceptable speed. Traction control is the reverse of an ABS. When a vehicle speeds up and the wheels turn faster than the car is moving, the tires will start sliding. The sensor sends this message to a computer that decreases the amount of fuel to the engine to slow down the wheels.

(b) When a car is experiencing understeering (force of friction on the front wheels is not enough to prevent the car from travelling in a straight line while the driver is making a turn) or oversteering (the car turns more than the driver intended and the back wheels start to slide sideways, spinning the car around), the ESC comes into play. An ESC can activate one or more brakes using an ABS to slow down the car or adjust the speed of the car using traction control.

10. Crumple zones in a car are designed to crush during an accident. The crushing action increases the time it takes to stop the car, reducing the acceleration of the occupants and the force acting on them. As a result, the occupants are more likely to survive the accident uninjured.

11. One of the safety innovations is a pretensioner. The pretensioner pulls in on the seat belt when a computer detects a crash. During a sudden stop, the seat belt is reeled in to keep a person in the optimal crash position in the seat, reducing the force acting on the person. Another seat belt safety innovation is a load limiter. A fold is sewn in the belt material. When a person in an accident is pushed forwards on the seat belt with a large force, the stitching breaks to give the belt a greater length, decreasing the force acting on the person.

12. (a) An airbag is a thin nylon bag folded into a car steering wheel or dashboard. It has a sensor that inflates the bag when a collision is detected to protect occupants of the vehicle.

(b) An airbag rapidly inflates and pushes out at a speed high enough to stop a driver or passenger from moving forwards when a car comes to a sudden stop.

(c) With a deployed airbag, the person collides with the airbag instead of the dashboard or steering wheel. As the person collides with an airbag, it compresses. This increases the time of collision, which further reduces the force acting on the person.

13. Answers may vary. Sample answer:

The Uniform Tire Quality Grading rating is made up of three components. The tread wear grade is a comparative rating based on the wear rate of the tire when tested under controlled conditions on a specified test track. A tire graded 200 would wear twice as long under specified test conditions as one graded 100. Tire traction grades, from highest to lowest, are AA, A, B, and C. They represent the tire's ability to stop on wet pavement as measured under controlled conditions on specified test surfaces of asphalt and concrete. The testing does not take into account cornering, hydroplaning, or acceleration. The higher the grade, the shorter the stopping distance on wet pavement. The temperature grades, from highest to lowest, are A, B, and C. These represent the tire's resistance to the generation of heat.