

LESSON PLAN – Drag’s Racing Suit

Academic Subject: Physics, physical science

Academic Topics: Fluid dynamics, drag

Background: For a competitive swimmer like Amanda Beard, experiencing drag when swimming through the water can be a real, well, drag. It turns out there isn’t just one type of drag that that this Olympic gold-medalist has to contend with – there are actually three forms. By choosing the right racing suit, she may be able to reduce some forms of drag, and move even faster through the water.

Discussion: The first type of drag that swimmers encounter is called wave drag. This is the strongest of the three. As a swimmer moves through the water waves build up around him/her. Lane dividers are used in races so that a swimmer is less affected by the waves created by other swimmers racing nearby. Wave drag only occurs at the surface, so swimmers try to take advantage of this with strong, underwater pullouts. After a Japanese swimmer won a gold medal in the 1956 Summer Olympics by swimming his breaststroke event almost entirely underwater, rules were implemented to limit how long a swimmer can remain underwater and avoid wave drag. During breaststroke a swimmer’s head must break the surface on every stroke, and on turns an underwater pullout is limited to 15 m.

The second type of drag is form drag. Just as a skydiver encounters air resistance when moving through the air, a swimmer is slowed down by the water he/she must push out of the way. Trailing the swimmer is an area of low pressure called a wake. The more streamlined the swimmer is, the easier the swimmer can cut through the water, and the smaller the wake that results. Racing suits fit very snugly to help contain a swimmer’s mass and make the swimmer more streamlined. The tiny ridges on a racing suit also help to combat form drag. Just as the dimples on a golf ball help to break up the air that swirls around it during flight, the rough surface of the suit helps to move the swimmer faster through the wake.

The final type of drag is friction / resistance drag. Any time an object is trying to slide past another object friction between the two objects will result. The more surface area an object has and the rougher it is, the greater resistance the resistance will be as it tries to move past something else. To reduce surface area swimmers wear bathing caps and tight swim suits. By shaving, swimmers attempt to make their bodies smoother. Swimmers do not want to make their bodies too smooth however. They must still have enough friction to pull through the water.

As a result of all of this drag, a swimmer swimming at a speed of 2 m/s experiences a total average drag force of about 110 N. In a 50-meter race, the swimmer must do 5500J of work just to overcome drag.

$$Work = force * dist$$

$$W = (110N)(50m)$$

$$W = 5500J$$

Extending the Lesson:

Students riding in a car as passengers can stick their hands out the window, but keeping them very close to the car for safety reasons. Hands should first be extended perpendicular to the ground and then arms should be rotated parallel to the ground. The form drag acting on the hand will be much less in the second case as the hand is much more streamlined and cuts through the air more easily.

ACTIVITY SHEET

1. Every time Amanda Beard pushes off the wall in a breaststroke race she does one stroke underwater. What is the advantage of doing this?
2. When Michael Phelps completes a turn in backstroke, he pushes off the wall with his arms extended behind his head in a V-shape. Why does he arrange his arms in this way?
3. Name two things that swimmers do to reduce friction drag.
4. Why are lane dividers used at swim meets? Why are they only at the surface?

ANSWERS

1. Amanda avoids the wave drag that occurs at the surface when she completes a stroke underwater.
2. The V-shape makes Michael more streamlined and allows him to cut through the water more easily.
3. Competitive swimmers wear swim caps and completely shave their bodies to reduce friction drag.
4. Lane dividers help to contain the waves created by a swimmer into just that swimmer's lane. This way other swimmers nearby don't have to battle those waves on top of the ones that they are creating. Lane dividers are located at the surface only because this is where the waves created by swimmers occur.