Page No	Current version	Corrected version
602	**11–25E** To reduce the drag coefficient and thus to improve the fuel efficiency, the frontal area of a car is to be reduced. Determine the amount of fuel and money saved per year as a result of reducing the frontal area from 18 to 15 ft^2. Assume the car is driven 12,000 mi a year at an average speed of 55 mi/h. Take the density and price of gasoline to be 50 lbm/ft^3 and \$2.20/gal, respectively; the density of air to be 0.075 lbm/ft^3, the heating value of gasoline to be 20,000 Btu/lbm; and the overall efficiency of the engine to be 32 percent.	11-25 To reduce the drag coefficient and thus to improve the fuel efficiency, the frontal area of a car is to be reduced. Determine the amount of fuel and money saved per year as a result of reducing the frontal area from 1.6 to 1.35m^2. Assume the car is driven 19000km a year at an average speed of 85km/h. Take the density and price of gasoline to be 800kg/m^3 and \$1.0/L, respectively; the density of air to be 1.2kg/m^3, the heating value of gasoline to be 10,000 Btu/kg; and the overall efficiency of the engine to be 32 percent.
602	**11–26E** Reconsider Prob. 11–25E. Using EES (or other) software, investigate the effect of frontal area on the annual fuel consumption of the car. Let the frontal area vary from 10 to 30 ft^2 in increments of 2 ft^2. Tabulate and plot the results.	11-26 Reconsider Prob. 11-25. Using EES (or other) software, investigate the effect of frontal area on the annual fuel consumption of the car. Let the frontal area vary from 1.0 to 3.0m^2 in increments of 0.2m^2. Tabulate and plot the results.
602	**11–28E** Wind loading is a primary consideration in the design of the supporting mechanisms of billboards, as evidenced by many billboards being knocked down during high winds. Determine the wind force acting on an 8-ft-high, 20-ft-wide billboard due to 90-mi/h winds in the normal direction when the atmospheric conditions are 14.3 psia and 40°F. *Answer: 6684 lbf*	11-28 Wind loading is a primary consideration in the design of the supporting mechanisms of billboards, as evidenced by many billboards being knocked down during high, winds. Determine the wind force acting on an 2.4m high, 6m wide billboard due to 140km/h winds in the normal direction when the atmospheric conditions are 98kPa and 4.5°C.
602	**11–31E** At highway speeds, about half of the power generated by the car's engine is used to overcome aerodynamic drag, and thus the fuel consumption is nearly proportional to the drag force on a level road. Determine the percentage increase in fuel consumption of a car per unit time when a person who normally drives at 55 mi/h now starts driving at 75 mi/h.	11-31 At highway speeds, about half of the power generated by the car's engine is used to overcome aerodynamic drag, and thus the fuel consumption is nearly proportional to the drag force

		on a level road. Determine the percentage increase in fuel consumption of a car per unit time when a person who normally drives at 90km/h now starts driving at 120km/h.
603	**11–37E** A 5-ft-diameter spherical tank completely submerged in freshwater is being towed by a ship at 12 ft/s. Assuming turbulent flow, determine the required towing power.	11-37 A 1.5m spherical tank completely submerged in fresh water is being towed by a ship at 36.m/s. Assuming turbulent flow, determine the required towing power.
603	**11–42E** The drag coefficient of a vehicle increases when its windows are rolled down or its sunroof is opened. A sports car has a frontal area of 18 ft^2 and a drag coefficient of 0.32 when the windows and sunroof are closed. The drag coefficient increases to 0.41 when the sunroof is open. Determine the additional power consumption of the car when the sunroof is opened at (*a*) 35 mi/h and (*b*) 70 mi/h. Take the density of air to be 0.075 lbm/ft^3.	11-42 The drag coefficient of a vehicle increases when its windows are rolled down or its sunroof is opened. A sports car has a frontal area of $1.6m^2$ and a drag coefficient of 0.32 when the windows and sunroof are closed. The drag coefficient increases to 0.41 when the sunroof is open. Determine the additional power consumption of the car when the sunroof is opened at (a) 55km/h and (b) 110 km/h. Take the density of air to be $1.2kg/m^3$.
604	**11–47E** Light oil at 75°F flows over a 15-ft-long flat plate with a free-stream velocity of 6 ft/s. Determine the total drag force per unit width of the plate.	11-47 Light oil at 24°C flows over a 4.5m long flat plate with a free-stream velocity of 1.8m/s. Determine the total drag force per unit width of the plate.
604	**11–50E** Air at 70°F flows over a 10-ft-long flat plate at 25 ft/s. Determine the local friction coefficient at intervals of 1 ft and plot the results against the distance from the leading edge.	11-50 Air at 21°C flows over a 3m flat plate at 7.5m/s. Determine the local friction coefficient at intervals of 0.15m and plot the results against the distance from the leading edge.
605	**11–55E** Consider a refrigeration truck traveling at 65 mi/h at a location where the air temperature is at 1 atm and 80°F. The refrigerated compartment of the truck can be considered to be a 9-ft-wide, 8-ft-high, and 20-ft-long rectangular box. Assuming the airflow over the entire outer surface to be turbulent and attached (no flow separation), determine the drag force acting on the top and side surfaces and the power required to overcome this drag.	11-55 Consider a refrigeration truck traveling at 100km/h at a location where the air temperature is at 1 atm and 27°C. The refrigerated compartment of the truck can be considered to be a 3m wide, 2.4m high, and 6m long rectangular box. Assuming the

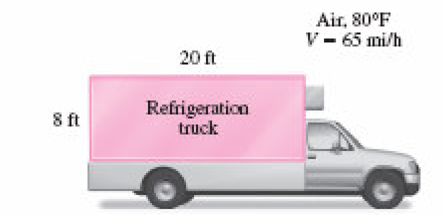
<table>
<tr><td></td><td></td><td>airflow over the entire outer surface to be turbulent, and attached (no flow separation), determine the drag force acting on the top and side surfaces and the power required to overcome this drag.</td></tr>
<tr><td>605</td><td>

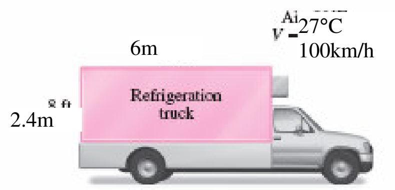
FIGURE P11–55E</td><td>

FIGURE P11-55</td></tr>
<tr><td>605</td><td>11–56E Reconsider Prob. 11–55E. Using EES (or other) software, investigate the effect of truck speed on the total drag force acting on the top and side surfaces, and the power required to overcome it. Let the truck speed vary from 0 to 100 mi/h in increments of 10 mi/h. Tabulate and plot the results.</td><td>Reconsider Prob. 11-55. Using EES (or other) software, investigate the effect of truck speed on the total drag force acting on the top and side surfaces and the power required to overcome it. Let the truck speed vary from 0 to 160km/h in increments of 10km/h. Tabulate and plot the results.</td></tr>
<tr><td>605</td><td>11–62E A 1.2-in-outer-diameter pipe is to span across a river at a 105-ft-wide section while being completely immersed in water. The average flow velocity of water is 10 ft/s, and the water temperature is 70°F. Determine the drag force exerted on the pipe by the river. Answer: 1320 lbf</td><td>11-62 A 3cm outer-diameter pipe is to span across a river at a 31m wide section while being completely immersed in water. The average flow velocity of water is 3m/s and the water temperature is 21°C. Determine the drag force exerted on the pipe by the river.</td></tr>
<tr><td>605</td><td>11–64E A person extends his uncovered arms into the windy air outside at 1 atm and 60°F and 20 mi/h in order to feel nature closely. Treating the arm as a 2-ft-long and 3-in-diameter cylinder, determine the drag force on both arms. Answer: 1.02 lbf</td><td>11-64 A person extends his uncovered arms into the windy air outside at 1 atm and 15.5°C and 32km/h in order to feel nature closely. Treating the arm as a 1.2m long and 7.5cm diameter cylinder determine the drag force on both arms.</td></tr>
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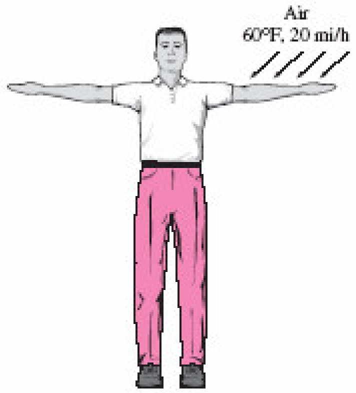
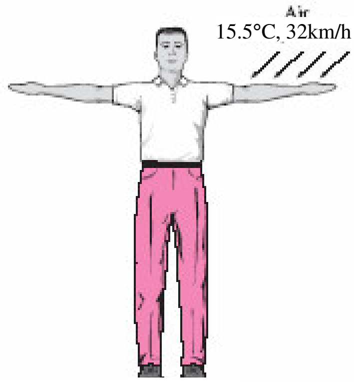
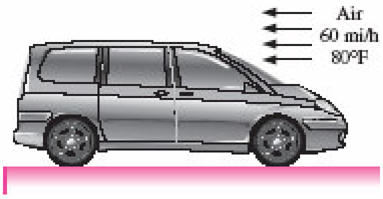
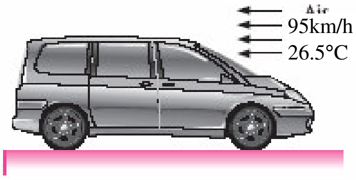
605	 FIGURE P11–64E	 FIGURE P11-64
607	**11–85E** An airplane is consuming fuel at a rate of 5 gal/min when cruising at a constant altitude of 10,000 ft at constant speed. Assuming the drag coefficient and the engine efficiency to remain the same, determine the rate of fuel consumption at an altitude of 30,000 ft at the same speed.	11-85 An airplane is consuming fuel at a rate of 19L/min when cruising at a constant altitude of 3000m at a constant speed. Assuming the drag coefficient and the engine efficiency to remain the same determine the rate of fuel consumption at an altitude of 9000m at the same speed.
607	**11–93E** A 2.4-in-diameter smooth ball rotating at 500 rpm is dropped in a water stream at 60°F flowing at 4 ft/s. Determine the lift and the drag force acting on the ball when it is first dropped in the water.	11-93 A 6cm diameter smooth ball rotating at 500rpm is dropped in a water stream at 15.5°C flowing at 1.2m/s. Determine the lift and the drag force acting on the ball when it is first dropped in the water.
608	**11–96E** The passenger compartment of a minivan traveling at 60 mi/h in ambient air at 1 atm and 80°F can be modeled as a 3.2-ft-high, 6-ft-wide, and 11-ft-long rectangular box. The airflow over the exterior surfaces can be assumed to be turbulent because of the intense vibrations involved. Determine the drag force acting on the top and the two side surfaces of the van and the power required to overcome it.	11-96 The passenger compartment of a minivan traveling at 95km/h in ambient air at 1 atm and 26.5°C can be modeled as a 1m high, 1.8m wide, and 3.3m long rectangular box. The airflow over the exterior surfaces can be assumed to be turbulent because of the intense vibrations involved. Determine the drag force acting on the top and the two side surfaces of the van and the power required to overcome it.

608	 **FIGURE P11–96E**	 FIGURE P11-96
608	**11–101E** A commercial airplane has a total mass of 150,000 lbm and a wing planform area of 1800 ft^2. The plane has a cruising speed of 550 mi/h and a cruising altitude of 38,000 ft where the air density is 0.0208 lbm/ft^3. The plane has double-slotted flaps for use during takeoff and landing, but it cruises with all flaps retracted. Assuming the lift and drag characteristics of the wings can be approximated by NACA 23012, determine (*a*) the minimum safe speed for takeoff and landing with and without extending the flaps, (*b*) the angle of attack to cruise steadily at the cruising altitude, and (*c*) the power that needs to be supplied to provide enough thrust to overcome drag. Take the air density on the ground to be 0.075 lbm/ft^3.	11-101 A commercial airplane has a total mass of 67500kg and a wing planform area of $160m^2$. The plane has a cruising speed of 880km/h and a cruising altitude of 11400m where the air density is $0.45kg/m^3$. The plane has double-slotted flaps for use during takeoff and landing but it cruises with all flaps retracted. Assuming the lift and drag characteristics of the wings can be approximated by NACA 23012, determine (a) the minimum safe speed for takeoff and landing with and without extending the flaps, (b) the angles of attack to cruise steadily at the cruising altitude, and (c) the power that needs to be supplied to provide enough thrust to overcome drag. Take the air density on the ground to be $1.2kg/m^3$.