

Name: \_\_\_\_\_

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### Notes - 5.2 Drag

1. What other force is experienced when moving in a fluid (either a gas or a liquid)?

drag force

2. Like friction, the drag force always opposes the motion of an object.

3. For objects not moving too slowly, the drag force is proportional to the

square of the velocity.

4.  $F_D = \frac{1}{2} C \rho A v^2$

where

$C$  = drag coefficient

$\rho$  = density of the fluid  $[\frac{kg}{m^3}]$

$A$  = area of the object facing the fluid  $[m^2]$

5. Why is aerodynamic shaping of automobiles important?

reduces the drag force and improves the car's gas mileage

6. How is the drag coefficient  $C$  determined?

empirically, usually with a wind tunnel

7. List the drag coefficient of a

Sphere

0.45

Honda Civic

0.36

Sky Diver (horizontal)

1.0

8. List how drag is minimized in the following sports.

Golf:

dimples on golf balls

Swimming:

full body suit

9. Sky Diver Falling Through The Air

A. What are the two forces acting on the sky diver?

drag force & gravitational force



B. What is terminal velocity?

constant velocity



C. At terminal velocity,  $F_{Net} = 0$

D. At terminal velocity,  $F_D = F_g = mg \Rightarrow \frac{1}{2} C \rho A v^2 = mg$

E. At terminal velocity,  $v_T = \sqrt{\frac{2mg}{C\rho A}}$

10. Find the terminal velocity of an 85-kg skydiver falling in a spread-eagle (i.e. horizontal) position.

$$v_T = \sqrt{\frac{2mg}{C\rho A}} = \sqrt{\frac{2(85\text{kg})(9.8\frac{\text{m}}{\text{s}^2})}{(1.0)(1.21\frac{\text{kg}}{\text{m}^3})(0.70\text{m}^2)}} = 44\frac{\text{m}}{\text{s}}$$

11. Small Objects/Slow-Moving Objects/Dense Medium

A. The drag force is proportional to the object's velocity.

B. This relationship is known as Stoke's law.

C.  $F_s = 6\pi r \eta v$

where

$r =$  radius of the object  $[\text{m}]$

$\eta =$  viscosity of the fluid  $[\frac{\text{kg}}{\text{s}\cdot\text{m}}]$

$v =$  velocity of the object  $[\frac{\text{m}}{\text{s}}]$