3 Dynamics – Part 2

Name: ____________ Class: ________ Date: __________

Vocabulary 词汇

Write each word three times. 把每个单词抄写三遍。

English	中文	Write it 3 times (English)		
impulse	冲量			
friction	摩擦力			
drag	阻力			
terminal velocity	收尾速度			
elastic collision	弹性碰撞			
kinetic energy	动能			
relative speed	相对速率			
inelastic collision	非弹性碰撞			
deformation	形变			

Recall

In **Part 1** you used $F = ma$, Newton's three laws, and conservation of momentum. Keep ready:

- Momentum $p = mv$; the total momentum is conserved when no outside force acts.
- Weight $W = mg$.

Part 2 looks at force as the *rate of change* of momentum (impulse), motion with air resistance, and the two kinds of collision.

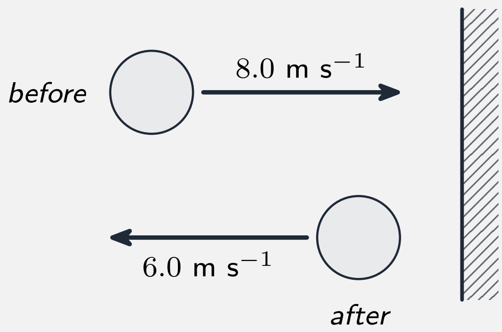
New ideas

■ 1 Impulse —force as change of momentum

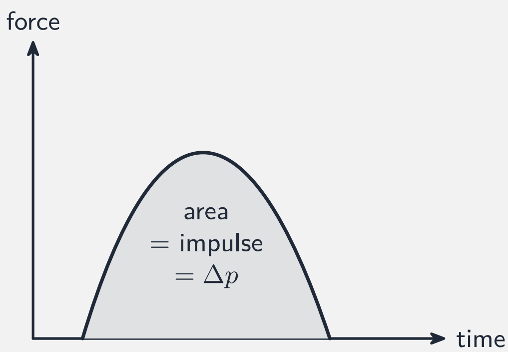
Newton's second law, in full: the resultant force equals the rate of change of momentum,

$$F = \frac{\Delta p}{\Delta t}.$$

So $\Delta p = F\,\Delta t$ —this change of momentum is the **impulse** 冲量. In a bounce the momentum **reverses**, so use signed (+/−) values.



Worked example. A 0.20 kg ball hits a wall at 8.0 m s^{-1} and bounces back at 6.0 m s^{-1}; contact lasts 0.050 s. Taking the rebound way as positive, $\Delta p = 0.20\,(6.0-(-8.0)) = 2.8$ kg m s^{-1}, so $F = \dfrac{2.8}{0.050} = 56$ N.



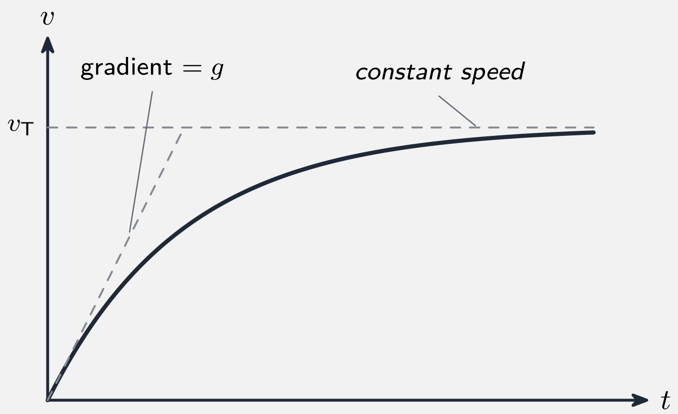
Watch out: in a bounce the momentum *reverses*, so use signed values —the change is the rebound velocity *minus* the (negative) incoming one, which is bigger than the speed change alone.

■ 2 Friction, drag and terminal velocity

A **friction** 摩擦力 force opposes sliding; a fluid (air, water) gives a **drag** 阻力 force that grows with speed. For an object dropped through air:

1. at first only weight acts → it speeds up at g;
2. as it speeds up, drag grows → the resultant force, and so the acceleration, get smaller;

3. when drag = weight the resultant is zero → it falls at a constant **terminal velocity** 收尾速度.



■ **3 Elastic and inelastic collisions**

Momentum is conserved in **every** collision. An **elastic collision** 弹性碰撞 *also* conserves **kinetic energy** 动能 (the **relative speed** 相对速率 of approach equals that of separation). An **inelastic collision** 非弹性碰撞 loses kinetic energy (to heat, sound or **deformation** 形变); if the objects stick together it is perfectly inelastic.

Worked example. A 1500 kg car at 12 m s^{-1} hits a stationary 1000 kg car and they lock together: $1500(12) = 2500\,v$, so $v = 7.2$ m s^{-1} (inelastic —kinetic energy is lost).

Practice

3.1 A steady force of 20 N acts on a trolley for 3.0 s. Find the impulse (the change in momentum). [2]

3.2 A 0.15 kg ball hits the floor at 4.0 m s^{-1} and bounces up at 3.0 m s^{-1}. Find the magnitude of its change in momentum. [2]

3.3 An object falling through air has reached its terminal velocity. State the resultant force on it, and explain why its speed stays constant. [2]

3.4 State whether each collision is elastic or inelastic: (a) two balls stick together; (b) two balls bounce apart with no loss of kinetic energy. [2]

3.5 A 2.0 kg trolley moving at 3.0 m s^{-1} hits a stationary 4.0 kg trolley and they couple together. Find their common velocity. [2]

3.6 Challenge. A car's crumple zone and air bag make a crash last *longer*. Using $F = \Delta p/\Delta t$, explain why this reduces the force on the passengers. [2]