Homework assignments

Self study	**Homework (to be handed in)**
Read: pp. 77-86 Note: pay special attention to pp. 79-80 Work through all the examples.	Exercise 6A: 5 Exercise 6B: 15 Exercise 6C: 4

6. Motion due to gravity

- Understand that motion upwards and downwards can be covered by a single set of equations, with velocity and displacement either positive or negative
- Appreciate the effect of friction for motion on a slope, and of air resistance for vertical motion

6.1 Objects falling from height

Acceleration due to gravity: $g = 10 \text{ m s}^{-2}$

$$v = u + at$$

$$s = ut + \frac{1}{2}at^2$$

$$v^2 = u^2 + 2as$$

Example 6.1.1

At a swimming pool a girl steps from a diving board 4 m above the surface of the water. How fast is she moving when her feet hit the water?

$$v^2 = u^2 + 2as$$

Example 6.1.2

A brick is dislodged from the top of a tall block of flats. A resident on a 10th-floor balcony sees it passing, and a second later hears it hit the ground. Each storey has a height of 2.5 m. How tall is the block of flats, and how fast is the brick moving when it hits the ground?

Class exercises
Exercise 6A

4 A ball is thrown downwards with an initial velocity of $3.5\ \text{m s}^{-1}$, and hits the ground when its velocity is $17.5\ \text{m s}^{-1}$. From what height was the ball thrown?

$$v^2 = u^2 + 2as$$

6.2 Objects moving upwards

Example 6.2.1

A ball is thrown vertically upwards and rises a height of 12.8 metres. Find the speed with which it was thrown, and its velocity when it has risen 11 metres.

$$v^2 = u^2 + 2as$$

Example 6.2.2

Juliet's balcony is 3.6 metres above the ground. Romeo throws a bunch of flowers up to her with a speed of $11\ \mathrm{m\,s^{-1}}$. Juliet responds by throwing him an orange, which she throws upwards with a speed of $3\ \mathrm{m\,s^{-1}}$. Find the time for which each gift is in the air, and the speed at which it is moving when it is caught.

Self study

Class exercises
Exercise 6B

11 A ball is thrown upwards with an initial velocity of 12 m s^{-1} from a point 2.5 metres above the ground. Find the time when the ball reaches the ground, and the velocity of the ball at this instant.

Acceleration due to gravity: $g = 10$ m s^{-2}

$$v = u + at$$

$$s = ut + \frac{1}{2}at^2$$

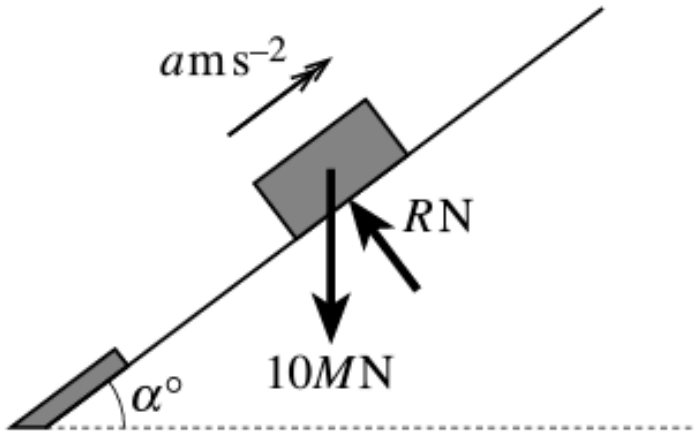
$$v^2 = u^2 + 2as$$

A small ball is projected vertically downwards with speed $5\ \mathrm{ms}^{-1}$ from a point *A* at a height of 7.2 m above horizontal ground. The ball hits the ground with speed *V* ms^{-1} and rebounds vertically upwards with speed 1/2*V* ms^{-1}. The highest point the ball reaches after rebounding is *B*. Find *V* and hence find the total time taken for the ball to reach the ground from *A* and rebound to *B*.

6.3 Motion on a sloping plane

Example 6.3.1

A path runs up a hillside, at an angle of $\alpha°$ to the horizontal, such that $\sin\alpha° = 0.6$ and $\cos\alpha° = 0.8$. A block is placed on the path, and is prevented from sliding down by a low kerbstone. The block is struck and starts to move up the path at a speed of $12\ \mathrm{m\,s^{-1}}$. The path is icy, so the effect of friction can be neglected. Find how far up the path the block moves, the speed with which it hits the kerbstone on its return, and the time it is in motion.



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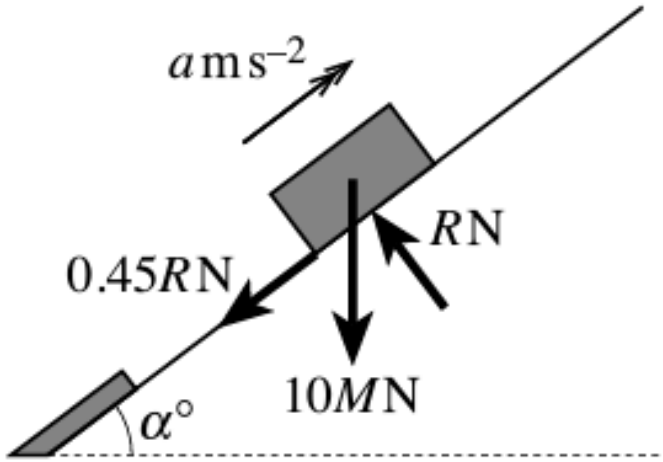
Example 6.3.2

Rework Example 6.3.1 when the ice has melted. The coefficient of friction between the block and the path is now 0.45.

Self study



2 A coin is thrown vertically upwards, with speed $5\ \text{m s}^{-1}$, from the top of a wishing-well. There is no water in the well and the coin hits the bottom of the well $3\ \text{s}$ after being thrown. Modelling the coin as a particle, and ignoring air resistance, calculate the depth of the well. (Old book) (OCR)

7 A very deep shaft is drilled vertically through the earth. When a brick is dropped into the shaft, the sound of the brick hitting the bottom is heard 7.7 seconds later. Taking the speed of sound to be $350\ \text{m s}^{-1}$, find the depth of the shaft.

6.4 Vertical motion with air resistance

The magnitude of frictional force is not dependent on speed

The magnitude of air resistance (drag force) is proportional to air density, speed, surface area of the object, material of the object.

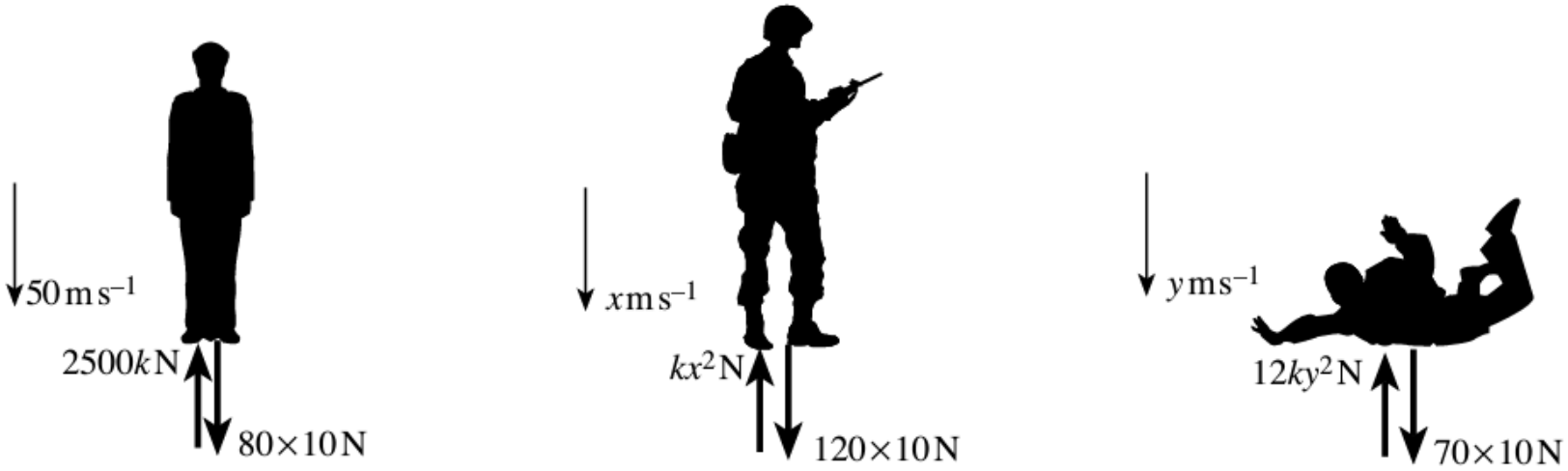
For relative low speeds we assume that air resistance is proportional to the square of the speed, i.e.:

$$F_D = kv^2$$

For falling object if air resistance becomes the same as gravity, the object falls at **terminal speed.**

Example 6.4.1

Three people step out of an aircraft, and fall vertically before opening their parachutes. The first, who has a mass of $80\ \text{kg}$, remains upright as he falls, and has a terminal speed of $50\ \text{m s}^{-1}$. The second is a soldier wearing heavy clothing and carrying equipment; his mass is $120\ \text{kg}$, and he also remains upright. The third is a skilled skydiver, of mass $70\ \text{kg}$, who takes up a horizontal position with arms and legs stretched out; this enables her to multiply the air resistance constant by a factor of 12. Find the terminal speed of the soldier and the skydiver.



6C (3)

A rock of mass 20 kg falls from a height. As it falls, it experiences air resistance of magnitude $0.08v^2$ newtons, where v is its speed in ms^{-1}. Find the terminal speed of the rock. With what acceleration will it be falling when its speed is 25 ms^{-1}?