AQA
Realising potential

TOPIC TEST

AS-level FURTHER MATHS

Impulse and Dimensional Analysis

Version 1.0

Specification content coverage: MA1 MA2 MB3 MB4

In this test you will be assessed on:

- finding the dimensions of familiar quantities with compound units.
- understanding the concept of a dimensionless constant.
- determining the power of each variable in a partially completed formula.
- predicting a formula, in simple situations.

- knowing and using a variety of formulas for impulse in one and two dimensions
- understanding that when two bodies collide, the impulse acting on each is equal and opposite.
- using $I = \int F \, \mathrm{d}t$ for a variable force.

Section A: The basics

1 State the dimensions of force.

[1 mark]

2 A ball is released from rest and falls a distance of h metres before reaching the Earth's surface.

The ball's velocity, in m s^{-1}, when it reaches the surface is given by the formula

$$v = \sqrt{2gh}$$

Identify any dimensionless constants in this formula.

[1 mark]

3 Show that the formula

$$Ft = mv - mu$$

Is dimensionally consistent

[3 marks]

4 (a) A particle of mass 3 kg is moving at a speed of 4 m s^{-1} along smooth horizontal ground.

The particle collides directly with a smooth vertical wall.

After the collision it moves directly away from the wall with speed 2.5 m s^{-1}

Find the magnitude of the impulse of the wall on the particle.

[3 marks]

4 (b) State the magnitude of the impulse of the particle on the wall.

[1 mark]

5 A particle of mass 0.5 kg is moving with velocity $\begin{bmatrix} 6 \\ 4 \end{bmatrix}$ m s^{-1}

An impulse is applied to the particle and it then moves with velocity $\begin{bmatrix} 12 \\ -4 \end{bmatrix}$ m s^{-1}

Find the magnitude of the impulse.

[4 marks]

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Section B: A bit more thinking

6 A particle of mass 2 kg is initially at rest. The particle then moves in a straight line under the action of a single force, F newtons.

It is given that

$$F = kt^2 + 4$$

where t is the time, in seconds, for which the force has been acting and k is a constant.

Given that the magnitude of the impulse exerted by the force on the particle from times t = 0 to t = 4 is 144 Ns, find the value of k.

[4 marks]

7 Harry thinks that the period, t seconds, of a simple pendulum is given by the formula

$$t = 2\pi\sqrt{\frac{g}{l}}$$

where l is the length of the string in metres and g is the acceleration due to gravity.

Use dimensional analysis to show that Harry is incorrect.

[4 marks]

8 A particle of mass 1.5 kg is moving in a straight line along a smooth horizontal surface, under the action of a horizontal force F newtons.

Initially the particle was at rest.

It is given that

$$F = 4t + 7$$

where t is the number of seconds for which the force has been acting.

Find the impulse of the force on the particle in its first 3 seconds.

Hence find the speed of the particle when t = 3.

[4 marks]

9 (a) The time, t, for a single vibration of a piece of taut string is believed to depend on

the length of the taut string, l,

the tension in the string, F,

the mass per unit length of the string, p,

and a dimensionless constant, k,

such that

$$t = kl^a F^b p^c$$

where a, b and c are constants.

By using dimensional analysis, find the values of a, b and c

[5 marks]

9 (b) Use your formula from part 7(a) to explain what happens to the time taken for a single vibration of the string when the tension in the string is doubled.

[2 marks]