Edinburgh Napier UNIVERSITY

Physics-Based Animation (SET09119)

Tutorial 04 - Motion Under Forces

1 Question

A particle has a mass of 100kg and has a 500N force applied to it.
(a) Find the acceleration.
(b) If the particle starts from rest, what is the speed after 4 seconds?

(a)

$$a = 5ms^{-2}$$

(b)

$$u = 0$$
$$v = ?$$
$$a = 5$$
$$t = 4$$
$$\therefore\ v = 20ms^{-1}$$

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2 Question

A particle of mass 12 kg has an acceleration of $5ms^{-2}$. (a) Find the force F?
(b) If the particle is initially at rest, what distance is covered in the first 4 seconds?

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solution:
(a)

$$F = 60N$$

(b)

$$s = 40m$$

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3 Question

Pull of an engine is F and the resistance to the motion is 80N. Initially the body is at rest. Force F = 120N is applied for 10 seconds in the opposite direction and removed. How long before it is back to rest and what will be the total distance covered? (mass=20kg)

$120 - 80 = 40$
$f = ma$
$a = \frac{40}{20}$
$a = 2ms^{-2}$

$$u = 0$$
$$v = ?\ (find\ first)$$
$$a = 2$$
$$s = ??\ (find\ second)$$
$$t = 10$$

$v = 20ms^{-1}$
$s = 100m$
Then
$f = -80N$
$f = ma$
$a = \frac{-80}{20}$

Then $a = -4ms^{-2}$

$$u = 20$$
$$v = 0$$
$$a = -2$$
$$s = ?\ (find\ first)$$
$$t = ??\ (find\ second)$$

$t = 5$ seconds
$s = 50$ metres
Total time = 5 + 10 = 15 seconds. Total distance = 100 + 50 = 150 metres.

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4 Question

A brick of mass 3kg falls through water with an acceleration of $2ms^{-2}$. Find the resistance force (gravity is $9.8ms^{-2}$).

$$(3)(9.8) = 29.4N$$
$$29.4 - R = (3)(2)$$

$$R = 23.4N$$

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5 Question

A 500 tonne train crashes into a buffer at 18 kmh^{-1} and depresses it 1.25 metres before coming to a rest. What is the force of impact from the train on the buffer? (Note, 1 tonne == 1000 kg).

$$u = 5$$
$$v = 0$$
$$a = ?$$
$$s = 1.25$$

500 tonnes == 500,000 kg.
$18kmh^{-1} => \frac{18}{(60)(60)}(1000) = 5ms^{-1}$

$$v^2 = u^2 + 2as$$
$$\therefore$$
$$(0)^2 = (5)^2 + 2(a)(1.25) => a = -10ms^{-2}$$

a = -10 ms^{-2}
F = (500000)(10) = 5 million Newtons (or 5,000,000 N).

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6 Question

A balloon 'weighs' 600 kg is drifting horizontally. Some ballast is then thrown out, so the balloon begins to accelerate upwards at 0.2 ms^{-2}. How much ballast was thrown out (gravity is $9.8ms^{-2}$)?

Upward thrust = weight = 5880N.
(i.e., f = ma)

$$5880 - (9.8)(m) = (0.2)(m)$$
solve for m
$$m = 588$$

$\therefore$ 12 kg is thrown out.

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7 Question

Two particles of mass '2m' and '4m' respectively are connected by a light inextensible string which passes over a smooth fixed pulley. The particles are released from rest with the parts of the string on each side of the pulley hanging vertically.
Find in terms of g and m as appropriate (i.e., g is the downward gravitational acceleration constant):
(a) the magnitude of the acceleration of the particles,
(b) the forces exerted by the string on the pulley.

Solution (a):
Downward force for each particle can be calculated using $f = ma$. We formulate two equations:

$$\begin{aligned} 4mg - T &= 4ma \\ T - 2mg &= 2ma \end{aligned} \tag{1}$$

$\therefore$ we have two equations and two unknowns, so we can solve for the acceleration:
$a = \frac{1}{3}g$

Solution (b):

$$T = 2\frac{2}{3}mg$$

The force exerted on the pulley is 2T.
$\therefore\ 2T = 5\frac{1}{3}mg.$

(Remember, the tensions at either end of a string is equal and opposite.)
