Edinburgh Napier UNIVERSITY

Physics-Based Animation (SET09119)

Tutorial 04 - Notes - Motion Under Forces

1 Forces & Motion

1.1 What do we mean by Force & Motion?

The connection between forces and motion is important. The relationship between mass, force, and acceleration allows us to model techniques to understand how objects move over time (e.g., particles and constraints).

- understand the relationship between acceleration and force
- distinguish between mass and weight
- work out forces given the accelerations
- solve problems involving interconnected particles

2 Mass and Weight

- An apple has a mass of 0.5kg, but on the moon, it would 'weigh' much less - in fact it would probably just float around
- On Earth - the apple is kept on the ground by its 'weight'
- Hence, weight 'depends on the gravity' and is based on the following Equation:
- $$Weight = (mass)(gravity)$$

  or

  $$W = mg$$
- Example: the weight of an apple is $(0.5)(9.8) = 4.9 Newtons$

2.1 Example Question

A brick has a mass of $1.5kg$. What is its weight?

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solution:
Weight = (1.5)(9.8) = 14.7N
(Note - weight is always measured in Newtons, and the mass is in kg).

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3 Force

- all forces are measured in Newtons
- weight is an example of a force
- the rule: Force = (mass)(acceleration) or F=ma, is known as Newton's Second Law

3.1 Question

An ice-yacht of mass 300 kg has an acceleration of $0.8ms^{-2}$. What force is needed to produce this?

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solution:

$$F = (300)(0.8) = 240$$

$\therefore$ force needed = $240N$

3.2 Question

A 6-tonne yacht is running before the wind. The wind produces a force of 350N and the water a resistance of 50N. Find the acceleration of the yacht.

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solution:
$\therefore$ 350-50 = 6000a
$=>$ $a = 0.05ms^{-2}$

3.3 Question

Six dogs pulling a 1500 kg sledge over level snow keep it going at constant speed. Eight dogs give it an acceleration of 0.3 ms^{-2}. What forces does each dog pull?

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solution:
First, lets say the force for each dog is D.
Steady speed => no acceleration => no overall force.
$\therefore$ Resistance = 6D
With 8 dogs we have:

$$8D - 6D = (1500)(0.3)$$

$$D = 225$$

Hence, each dog has a pulling force of $225N$

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4 Interconnected Particles

We can represent complex systems using low-dimensional approximations - for example, a car pulling a caravan, a train pulling a string of coaches, or a rope slung over a beam with weighs at either end. The method is solved by understanding that we can divide the problem into separate equations using $F = ma$.

- a rope with 2000N pulling on each end - hence both forces are matched and the rope doesn't move - hence the force on the rope is 2000N (i.e., not 4000N)
- if a rope is taut - the tension at either end will be the same (e.g., even if the rope is slung over a beam - provided the beam is smooth with no friction)

5 Question

A car of mass 900kg tows a caravan of mass 700kg. If the driving force from the engine is 320N, find the force transmitted through the tow-bar and the acceleration of the car.

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solution:
Let T be the tension at either end (i.e., between the car and caravan).
Now using f=ma on the car and caravan 'separately'
Caravan: $T = 700a$
Car: $320 - T = 900a$
Hence, we have two equations and two unknowns (i.e., simultaneous equations):
$\therefore$ The force is 140N and the acceleration is $0.2ms^{-2}$.

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6 Summarize

- Forces are measured in Newtons
- A steady speed in a straight line means no acceleration (and so no overall force)
- The tension at either end of a taut rope is the same
- Weight = (mass)(gravity) or $W = mg$
- Force = (mass)(acceleration) or $f = ma$
- You should be able to solve problems of interconnected particles - and apply them to practical situations (e.g., pulling objects,