
Managing your Body Mass
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the cool joule

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www.managingyourbodymass.com

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About

This e-book has its origin in modules on energy presented by the author in postgraduate degree programmes on Sustainable Development and Spatial Planning.

Many of the students on the courses, with primary degrees in non-science areas such as law and planning, experienced some difficulty in their engagement with the concepts and units in energy.

Part of the complication arose from the use of the International System of Units or “SI” after the French title: *Systéme Internationale d'Unités.*

(The SI has come into use in science and engineering over the past thirty to forty years; it is a development of the old metric system of units.)

In an attempt to make the subject more “palatable”, examples on a personal level were taken from food energy input, and energy output in exercise and activity and introduced in the material.

In recent years, in addition to general energy and environmental matters, it is very obvious that overeating leading to obesity with its consequent health risks, has become an important private and public health issue.

As a result, the opportunity has been taken to present the subject of energy more widely; it is approached here from a different starting point – the personal level, summarised by the title, “managing your body mass”.

The author is an engineer and has worked in the energy area throughout most of his career.

He has no special expertise in nutrition or physiology – the views on these topics presented here are mainstream, well developed in the literature and promoted by public health organisations throughout the world.

The sole innovation is their presentation in SI units and in a different format, with some minor observations based on personal experience.

Managing your Body Mass

Introduction

This e-book is about energy, in particular energy at a personal level, and the units in which it is considered.

It is directed principally to the non-technical person and has the general aim of assisting people manage their body mass, as part of a broader good health objective.

It has the specific objectives:

First:

Knock out the calorie!

The **calorie** is an old, technically obsolete, metric unit of energy that has been used in nutrition for a very long period, well before serious attempts were made to introduce metric units in general to the UK and US.

It is so well established in the English-speaking world that most people do not recognise it as a metric unit.

Why knock it out? *(It's nothing personal.)*

Like most aspects of the scientific and technical world, the metric system of units has developed and its modern form, called the International System of Units, has replaced it.

The International System of Units or "SI" after the French title, *Systéme Internationale d'Unités,* has been adopted in principle across the world, including the UK and US.

HOWEVER, there is a problem:

The calorie is not the unit of energy in the SI.

Replace the calorie with what?

Replace it with the "**joule**", which is the unit of energy in the SI.

Second:

Break the linkage of the kilogram with weight.

In the International System of Units, it is as absurd to say “my weight is 60 kilograms” as to say “my weight is 60 seconds”.

The kilogram is the unit of mass in the SI; the **“newton”** is the unit of force or weight.

“Weight” is the gravitational force on objects on earth; in the SI the newton is the unit of weight.

Well, what do I say?

You say: ***My body mass is 60 kilograms.***

This ties in with the usage of “body mass index” as a general health indicator.

In the SI, if you really want to talk about your weight – your gravitational force on planet Earth, your “Earth-force” – you could say, to avoid confusion:

My Earth-weight is 600 newtons or *My Earth-force is 600 newtons.*

Numerically, in SI, your weight on Earth is simply ten times your body mass. On another planet or on the moon, your weight will be different:

My Mars-weight is 240 newtons / *My Moon-weight is 96 newtons*

Your body mass remains the same at 60 kilograms.

Third:

Move the SI up front and personal.

Managing your body mass places emphasis on:

- Your general good health. *Your body mass index.*
- Your food energy intake: *Count your joules.*
- Your diet structure: *As easy as 1-2-3 or 10-20-30.*
- Your energy output: *More time on your feet.*

In addressing these issues, the International System of Units becomes relevant in a very personal way.

The cool joule

The SI unit of energy: the joule

What is a *joule*? A joule (pronounced as in cool; symbol, J) is a unit of energy. It is approximately one quarter of a calorie – so one calorie equals four joules.

What is a *watt*? A watt (symbol, W) is a joule per second (in symbols, J/s). It is the unit of *power* – the rate of energy transfer.

And, "watt's a joule"? A joule is also a watt-second (symbol, Ws); it is the amount of energy transferred during one second in a process operating at one watt.

60 W

A traditional incandescent light bulb with a power rating of sixty watts (in symbols, 60 W) has an energy transfer rate of sixty joules per second (60 J/s).

In one second, there is a transfer of 60 joules: a conversion of 60 joules of electrical energy to an output of 60 joules of light and heat.

In one hour, there is an energy transfer of 216000 joules or 216 kilojoules (216 kJ).

In one day, there is an energy transfer of 5184000 joules, i.e. 5184 kilojoules or 5.184 megajoules (5.184 MJ).

5.2 MJ/d

Alternatively, in one day the energy transfer is 60 W over 24 hours: 60 x 24 = 1440 watthours or 1.4 kilowatthours (1.4 kWh).

1.4 kWh/d

Your electricity bill shows consumption in kWh.

The joule is the unit of energy in a system of units known as the International System of Units or "SI" after the French title: *Systéme Internationale d'Unités.*

In regard to energy, the SI makes significantly simpler the explanation of the basic concepts that are involved in the management of body mass.

Energy input in food is in joules; energy output in exercise and metabolism is in joules; and energy stored in the body is in joules.

A heartbeat

A typical energy transfer rate for a woman at rest is about 60 W – her *metabolic rate* or metabolic power.

An intricate complex of processes ultimately converts food energy to a thermal output and some movement.

Thermally, you're heated to a core body temperature of ~37°C; movement is most noticeable in breathing, and the beating of your heart.

Your heart operates with an output of about one watt, in terms of the power (J/s) required to pump blood around your body.

Each heartbeat is about one joule. In one hour you have, say, 4000 heartbeats, i.e. 4000 joules or four kilojoules.

Over a day it is nearly 100 000 heartbeats, in energy terms 100 kilojoules (100 kJ).

Some time-out for reflection?

The calorie / Calorie / kilocalorie jumble

Currently, the energy unit most widely known to the general public is the "calorie". Unfortunately, a confusion is possible as there are two versions: the "calorie" and the "Calorie", not distinguishable when spoken and very often not differentiated when written.

The Calorie is one thousand times the calorie and should be more exactly referred to as the kilocalorie (kcal), which is more likely to be used by professionals in nutrition rather than the public.

However, it is generally assumed by the technically interested that when the word is used, it is a shortened form of "kilocalorie".

Confusing: what about calling a "kilogram" a "gram" or a "kilometre" a "metre"?
As Humpty Dumpty said: "When I use a word it means just what I choose it to mean – neither more nor less."

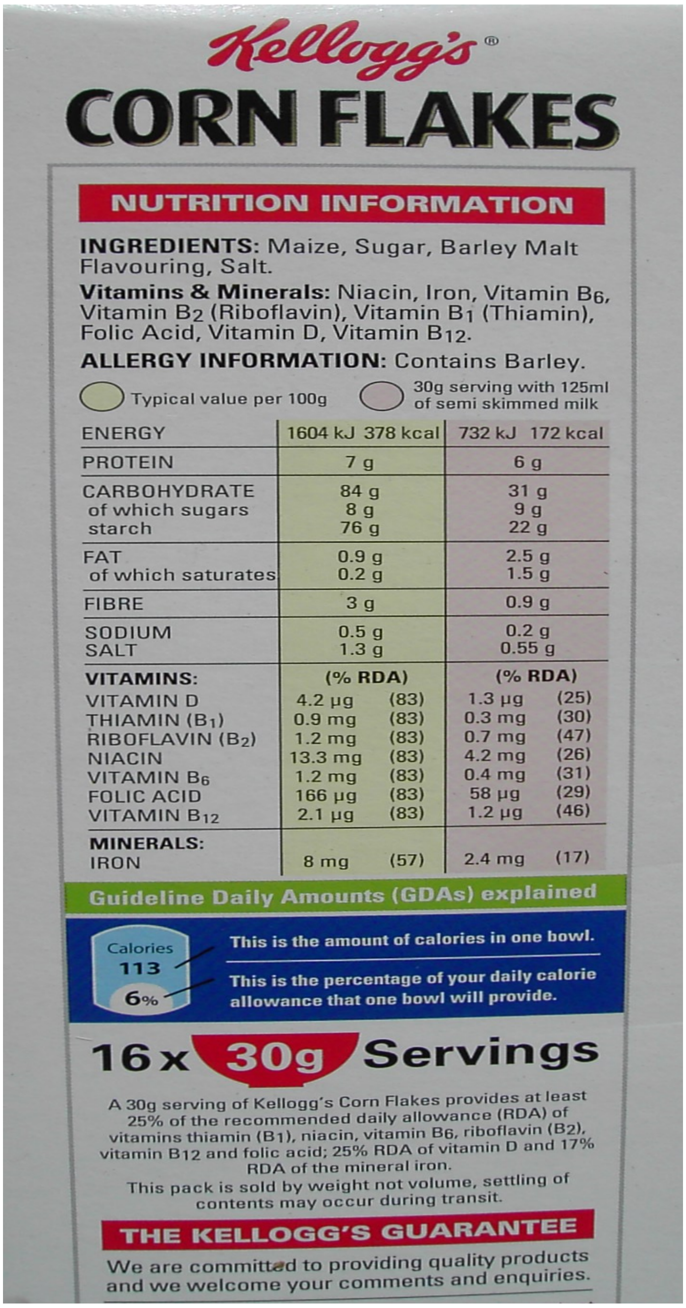
Energy Units on Food Packaging

Detailed nutritional information presented on food packaging is regulated by the EU and other jurisdictions.

In the EU, figures are presented in values per 100 grams (100 g) and per serving; energy units are in both kilojoules (kJ) and kilocalories (kcal).

Illustrated is a well-known cereal, Kellogg's Corn Flakes: the package (2013) is shown with data in yellow for 100 g of the cornflakes, and in gray/pink for a 30 g serving with 125 millilitres (125 ml) of semi-skimmed milk.

Major constituents are given in grams (g); vitamins and minerals in milligrams (mg) and micrograms (µg).



Guideline Daily Amounts

Also presented is the energy content of a serving of the cereal only (113 "Calories") and as a percentage (6%) of a "Guideline Daily Amount".
The Guideline Daily Amount for energy is 2000 "Calories" – meaning a daily energy intake of 2000 kcal, implicitly for an average adult.

The message generally on food packaging is that there is a single Guideline Daily Amount (GDA) of 2000 kcal, sometimes presented with qualifications for "active men" and "younger children".
Formerly on packaging, the GDA was explicit with two values shown: 2000 kcal for women and 2500 kcal for men.

In their development of the GDA in 2010, the ***Confederation of the food and drink industries of the EU*** (or ***CIAA)*** decided:

> The GDA values shown on a food or drink label should be those for an average "adult".
>
> For labelling purposes it was agreed that the GDA values currently used for women be used as figures for all adults.
>
> This also prevents the confusion of employing a new set of values based on the average GDA between males and females.

Nevertheless, apart from labelling, the actual CIAA position is that the GDA of 2500 kcal for men is still very much alive:

CIAA agreed reference values for GDAs

Nutrient	CIAA Recommended GDAs (proposed values) for women	CIAA Recommended GDAs (proposed values) for men
Energy	2000 kcal	2500 kcal
Protein	50 g	60 g
Carbohydrate	270 g	340 g
Fat	70 g	80 g
Saturated fat	20 g	25 g
Fibre	25 g	25 g
Sodium (Salt)	2.4 g (6 g)	2.4 g (6 g)
Sugars[1]	90 g	110 g

[1]Value agreed by majority of the working group.

CIAA: *Confederation des industries agro-alimentaires de l'UE*

One could argue that the CIAA statements do not result in complete clarity.

However, there is a very definite outcome: the GDA for women of 2000 kcal is the one that is now displayed on food packaging and is used for calculation of percentages.

As stated by the CIAA, adoption of a single GDA for energy does have the advantage that only one figure has to be presented as a percentage, as shown in the illustration:

Calories	
113	This is the amount of calories in one bowl.
6%	This is the percentage of your daily calorie allowance that one bowl will provide.

In general, regarding information on food packaging there is a case for even more clarity as the term "allowance" is also used in "**Recommended Daily Allowance (RDA)**" for the intake of salt, vitamins and minerals.

Other terminology in use is "**reference intake**" and in the US, "**daily value**".

Reference Intake

In revised legislation on food nutrition labelling, the EU will require mandatory declaration of the nutrition content of packaged foods (as opposed to a requirement only when a nutrition claim is made) to be fully implemented from December 2016.

The Regulation provides that: *the energy value and amounts of nutrients may be expressed, as appropriate, as a percentage of the reference intakes set out* in annexes to the Regulation.

When this is done, the following statement is mandatory:

*Reference intake of an average adult (*8400 kJ / 2000 kcal*)*

This is based on the advice of the European Food Safety Authority (EFSA):

EFSA Panel on Dietetic Products, Nutrition and Allergies

*The proposed labelling reference intake for energy (*8400 kJ *or* 2000 kcal*) corresponds to the recommended energy intake for a moderately active woman.*
The Panel considers that a labelling reference intake for energy based on intakes of women (as compared with a higher value based on intakes of men) gives a greater emphasis to the relative significance of a food as a source of energy, total fat, saturated fat and sugars and is more consistent with dietary advice for the general population on avoiding excess intakes of energy and these nutrients.

http://www.efsa.europa.eu/en/efsajournal/pub/1008.htm

The selection of a reference intake of 2000 kcal per day for an average adult means, in effect, that women retain their traditional benchmark while men have a new benchmark 20% lower than their traditional one.
Applying the same principle to women, their revised benchmark would be 1600 kcal per day.

United States – Percent Daily Value

In the US, food packaging has a strictly regulated **Nutrition Facts** label where the composition of the product is shown in grams, but per serving only.

Illustrated is the content (of part of the label) showing the major constituents for the corresponding US cereal product:

Nutrition Facts		
Serving Size 1 Cup (28g)		
Amount per Serving	**Cereal**	**with 1/2 cup skim milk**
Calories Calories from Fat	100 0	140 0
	% Daily Value**	
Total Fat 0g*	**0%**	**0%**
Saturated Fat 0g	**0%**	**0%**
Trans Fat 0g		
Polyunsaturated Fat 0g		
Monounsaturated Fat 0g		
Cholesterol 0mg	**0%**	**0%**
Sodium 200mg	**8%**	**11%**
Potassium 45mg	**1%**	**7%**
Total Carbohydrate 24g	**8%**	**10%**
Dietary Fiber 1g	**4%**	**4%**
Sugars 3g		
Protein 2g		

* Amount in cereal.

** Percent Daily Values are based on a 2,000 calorie diet. Your daily values may be higher or lower depending on your calorie needs:

The energy content is shown per serving; if displayed in kilojoules it would read:

Amount per Serving	**Cereal**	**with 1/2 cup skim milk**
Energy kilojoules Energy from Fat kJ	420 0	590 0

"**Percent Daily Values**" of major constituents such as fats and carbohydrates, as well as minerals and vitamins provided in the serving are displayed on the panel.

The panel has a note which states:

> Percent Daily Values are based on a 2,000 calorie diet. Your daily values may be higher or lower depending on your calorie needs.

It then lists the appropriate Daily Values for the 2000 kcal diet and a 2500 kcal diet.

"Calories" are not listed per 100 g or stated as a percentage of the 2000 kcal diet.

Nutrition Facts Label – Update

In early 2014, the US Food and Drug Administration announced an update of the Nutrition Facts label which will include a revised format to feature a much more prominent display of the energy content of the food serving:

http://www.fda.gov/NewsEvents/Newsroom/PressAnnouncements/ucm387418.htm

The FDA goes through a public consultation process before finalising its proposal and bringing it into law.

Other Jurisdictions

See Wikipedia for an outline of requirements for nutrition labelling in other jurisdictions.

Guideline Daily Amount: Energy

As seen, guideline daily amounts of energy are presented on EU packaging but not on US food packaging.

Is it necessary to present a single GDA for energy?

It is dubious, when one considers:

- it applies to both men and women,
- the range of their physical sizes,
- their ethnic backgrounds,
- their ages, and
- the spread of their occupations / activities.

A single guideline would seem to have only the most general relevance on an individual basis.

An alternative to a "guideline" amount of energy is simply to follow US procedure: show energy content per serving and combine it with the EU percentage approach, but based only on SI units.

A Standard Daily Amount of Energy (SDA): ten megajoules (10 MJ)

What is proposed here is to break away from the calorie/Calorie/kilocalorie jumble and attach solely and firmly to the SI unit: the joule.

In order to have a smooth transition and avoid losing audience, there must be an easy and convenient link/bridge to the old system.

The link lies in the traditional guideline daily amount for men: 2500 kcal.

To convert this figure to kilojoules, one multiplies by a conversion factor used in nutrition of 4.184 kJ per kilocalorie, which yields 10460 kJ as the guideline daily amount for men.

10460 is not a convenient number; 10000 is.

<u>Defining</u> **10000 kJ** as a "**Standard Daily Amount of Energy**" or "**SDA**" introduces yet another acronym but it does have advantages.

*Ten million joules per day, ten megajoules per day (*10 MJ/d*) averages 115.7 joules per second or just 116 watts.*
116 watts over 24 hours is just less than 2.8 kilowatt-hours; it is approximately 3 kWh.

Scale: 0 – 100% SDA

Since **10000 kJ** can be written as 100 00 kJ (100 hundred kilojoules), on a percentage scale it is **100% SDA**. Consequently:

1% SDA is **100 kJ**. And consequently:

The energy content of the cornflakes in the illustration of **1604 kJ** (sixteen hundred and four kilojoules) per 100 g may be immediately read as **16% SDA** per 100 g.

The energy content of a "30 g serving with 125 ml of semi skimmed milk" is **732 kJ**; it may be directly read as 7.3% SDA or **7% SDA** (rounded off).

7% SDA is 7% of the traditional amount of the daily energy input for an adult male.

Scale: 0 – 10 MJ

In addition, as **10000 kJ** are ten megajoules (**10 MJ**), one also has a scale of **0-10** where the top of the scale, **10**, may be taken as the traditional amount (2500 kcal) for men and **8** is that (2000 kcal) for women.

Labelling: Converting Calories to SDA %

European Union

In regard to current EU packaging, **front of package display** does not display kilojoules per serving.

It just shows "Calories" per serving (of the cereal only, for the example product) as well as the corresponding percentage based on the 2000 kcal diet:

Each 30g serving contains

Calories	Sugars	Fat	Saturates	Salt
113	**2.5g**	**0.3g**	**0.1g**	**0.4g**
6%	**3%**	**<1%**	**<1%**	**7%**

of the guideline daily amount

Convert to SDA %:

First option. Assume the percentage figure listed is the SDA %:

6% SDA.

The figure is too high by about one-fifth since the SDA base is ~2500 kcal *instead of* 2000 kcal.
However, you could use the listed figure and operate on the policy that you have a built-in "factor of safety".

Second option. Simply reduce the percentage figure by one-fifth:

5% SDA

Better still for such a product, which is not usually served alone, consult the back of the package for kilojoules per serving with milk. It yields: ***7% SDA.***

United Kingdom

In a revision (announced in 2013) to front of package display in the UK, the energy content of the serving will be shown in kilojoules and in kilocalories.
Values per 100 g will also be shown and the label will include the term:

% of an adult's reference intake

Colour coding for fat, sugars and salt will also feature.
The new measure will be on a voluntary basis.

Food labelling: Consistent system to be rolled out

United States

In the United States, the cereal product illustrated has a somewhat similar front of package display:

100 CALORIES	0g	200mg	3g SUGARS
	SAT FAT	SODIUM	
	0% DV	8% DV	
PER 1 CUP SERVING			

"Calories" per serving of the base product, as stated on the Nutrition Facts panel, is repeated; it is not expressed as a percentage of any daily amount.

To convert, multiply the ***CALORIES*** figure in hundreds by four to move to the SDA scale:
A food serving of 100 "Calories" is 4% on the scale; a food serving of 150 "Calories" is 6% on the scale.

Reform: Packaging Display

If SDA or equivalent were to rule, front of package display would show only one figure for energy per serving:

Per 30 g serving

ENERGY
5 %

Standard Daily Amount

Preferably, it should be separated from the current display of percentages of guideline daily amounts for the various nutrients and have a larger, highly legible format.

A major opportunity for a reform initiative will arise at the EU-US talks on a transatlantic free-trade area:

[The Transatlantic Trade and Investment Partnership](#)

[The biggest trade deal in the world](#)

SDA: A reference amount of energy

The Standard Daily Amount of Energy is simply a reference amount of energy, defined in SI units, that is numerically convenient for evaluation of human energy demand on a daily basis.

It is not a guideline amount but could be used to present such amounts in possibly a more understandable way than the standard 2000 / 2500 kcal model, as for example:

A person confined to bed, 50%; an office worker, 60%; a waiter, 80%; a farm worker, 120%; a professional rugby player, 200%; and if you are an aspiring sumo wrestler, maybe 300% SDA.

And, alternatively, in terms of megajoules, the above would read:
5, 6, 8, 12, 20, and 30 MJ.

Diet: Daily Structure

It would probably be of additional help to people in managing their food energy intake to specify the structure of that intake in more detail – it would certainly make it more individual.

The dietary input mentioned as a theme is:

As easy as 1-2-3 or 10-20-30.

10-20-30 refers to:
Breakfast, 10% Midday, 20% Evening, 30%

The total for the day on this diet is **60% SDA** (~1500 kcal).

1-2-3 refers to:
Breakfast, 1 MJ Midday, 2 MJ Evening, 3 MJ.

The total for the day on this diet is **6 MJ** (~1500 kcal).

Make it personal: for you it could be a **10-10-20** plus a **10-30**?

A total of **80% SDA** or **8 MJ** (~2000 kcal).

In summary:

- It is time that the calorie / Calorie / kilocalorie jumble should depart the scene.
- It should be replaced completely by the energy unit of the International System of Units as the sole unit of food energy, i.e. the joule.
- For convenience and practicality, a percentage approach should continue to be developed. It should be based on a standard per diem reference amount of energy – ten megajoules (10 MJ).
- The EU-US talks on an Atlantic free trade area provides an opportunity to initiate reform and unify food labelling on both sides of the Atlantic.
- The talks should also provide an opportunity to rectify the anomaly of not providing energy and nutrient information on the labelling of alcoholic beverages.

Overview

Managing your Body Mass

As the doctor most likely says: "Eat less and exercise more". Decrease energy input, increase energy output.

This does not appear such a problem when, stated technically and clinically, it is considered as an energy input, output, storage balance: simply adjust the amount in storage.

Simple in principle but difficult in practice, especially when humans are involved.

The general approach adopted here is to modify current lifestyle in terms of the magnitude of food energy input rather than making any radical dietary change.

The latter frequently turns out to be unsustainable as people eventually drop the new regime and revert to the previous one.

Similarly with exercise.

Reducing body mass

The most common problem is that body mass has been increased over a very long period and the individual has become accustomed to a large daily food input, in a sequence of major and minor rituals.

Instead of looking for a dramatic reduction in body mass, the strategy is to aim for incremental change and a habituation of the physical system to a new input-output balance.

The desired outcome is to obtain a gradual, steady reduction of body mass of about one kilogram per month.

This may seem very slow at the start but because one becomes habituated, the system demands less, it becomes self-reinforcing and later it may require a conscious effort to adjust course.

The critical decision

Many of us are brilliant managers of other people's affairs but when it comes to our own there is often a big shortfall.

In matters of personal health, even for professionals, the crucial step of translating what is intellectually obvious and accepted, is put on the long finger or implemented in some half-hearted New Year's resolution that just peters out.

And then comes a tipping point: that's it – no more messing around.

What to do about it?
Just start. Buy that scales and establish the facts.
Let's say, you have to put your BMI on your resume / CV: what number do you write down?
A horrible dream: you have to report to your boss or Board on your last effort. What do you say?

Program:

Key steps / features in a program of managing your body mass are:

1. Commit to your program.
   I'm going to do something about this, starting right now.

2. Analyse your current physical condition.
   Yes – an agonising reappraisal.

3. Analyse your current energy input in detail.
   What are you actually eating every day?

4. Analyse your current energy output in detail.
   What is your daily routine in detail – how much time on the couch?

5. Decide on your general targets.
   Your good health is important – is it not?

6. Plan your program.
   Take it easy – not too ambitious; but relentless.

7. Implement it.
   Back to commitment.

Practical steps:

Get a bathroom scales reading only in kilograms - one that is very easy to read.

Get a kitchen scales reading in grams and keep it on the counter ready for action.

Check that you have a tape to measure your height plus, in metres.

Get a notebook to record the facts - only necessary initially and later look-up. Alternatively, use your tablet / smart-phone.

The phone, with its camera, will enable you, if you wish, to make a very elaborate and detailed record of your food input. This extends to measurements on the kitchen scales as well as dining in restaurants and so on.

The recording of actual food input by individuals is notoriously unreliable, under-reporting being the general feature. Be aware of this and remember your particular record is for your eyes only – there is no need to varnish the facts.

Psychology:

Inform family members of your serious intent and look for support - nothing dramatic.

There is a practical implication as your household may involve others in food purchase, preparation and meals.

This is also a psychological move which puts you on the spot to deliver, and also enlists help - most people are interested.

The general theme is **10-20-30**: there is a food input "reward" as one goes through the day - something to look forward to.

Build in a free day – ***On the seventh day thou shalt rest*** – do as you like on the free day, eat as you wish. Relief and reward at the end of the week.

One finds, however, that restraint is not abandoned on the free day – the habituation process kicks in.

Identify those little habits / rituals that creep into one's life and that then must be strictly observed: savoury snacks at certain events, drinks at certain times, chocolates at other.

Devise alternatives / postpone / wean yourself off the practises.

For example, use a sugar-free gum as an evening snack substitute – you'll get the chewing activity without the energy input.

Introduce hurdles, such as changing the time of cleaning your teeth to after a meal instead of last thing at night.

Current Physical Condition:

Carry out a frank, maybe agonising, appraisal of your physical condition.

This means determining your body mass, your height, your waist and hip dimensions, your waist-hip ratio and your body mass index.

If you have not not been to the doctor for some time, now is opportune.

A comprehensive examination, including blood tests, will establish a benchmark by which you can judge your progress.

Let the doctor know your plans. S/he will also be interested.

In general, it is recommended that you consult your physician before embarking on any exercise/dietary program. There may be factors that, in your case, constrain that program.

That first stage of food processing, your mouth, is also worth some specialist attention. An assessment of your dental health and the impact of your diet will contribute to your appraisal.

Energy in – *Easy as 1-2-3 or 10-20-30*

The dietary theme for energy input throughout the day is:

Easy as 1-2-3 or 10-20-30

In the language of a Standard Daily Amount of Energy (SDA), 10-20-30 means:

Breakfast, 10%; mid-day, 20%; evening, 30%.

All food energy inputs are in terms of percentages:

a yogurt is 4%
a 40 g slice of bread is 4%
an apple is 1.5%
a glass of wine is 5%
and so on.

This theme distribution amounts to a total daily input of 60% SDA.

But YOU decide on your own personal distribution.

The theme applies six days a week.

You're as free as a bird on the seventh!

Energy out – Work out +

Reflecting on our evolutionary origins, as we all should do from time to time, and the lifestyle of our ancestors down to to say the relatively recent past of one to two centuries ago, one has to accept that vigorous, physical activity / work was a key feature of every day.

Make it a feature of your everyday – put into action the minimum benchmark activity as recommended by the various health organisations.

Say, a vigorous half-hour walk or equivalent (See: **Act / Move**).

What's the problem about starting today?

In general, spend more time on your feet.

Your Body Mass Index

An agonising reappraisal

Body mass

A very important measure of your physical condition is your body mass (BM). However, it is your body mass in relation to your height that is the critical determinant – it is known as the *body mass index*.

Your body mass is in kilograms; use your new scales to get your new benchmark value.

Approx: Torso 50%; legs 33%; arms 10%; head/neck 7%.

Compare the mass indicated by the new scales with your old one to give you a link with any previous measurements you might have noted.

Typical **clothed body mass** is also of interest: indoor and outdoor winter. You must carry the lot up the stairs, steps or hill.

Conversion

You may feel bereft that you have no fast link to your old weight measures in pounds or stones and lbs.

Pounds to kilograms:	*Divide by two*	*Better: Subtract 10%.*
180 pounds:	90 kg	90 - 9 = 81 kg
Stones and lbs. to kilograms:	*Round up – st.*	*Multiply by 6.*
8 st 7 lbs	9 st	54 kg

One kilogram weighs 2.2046 pounds.

Your height

Height barefoot, in metres, is your next measurement. Get a good fix on this.

In metric, the usual way to state your height is as in: “My height is one metre seventy five”. An alternative is: “My height is one seventy-five”.
These statements read as a height of 1.75 m.

It is not convenient to reach for the calculator every time one wants to convert to metric. An estimate in your head is often good enough to get a feel for the magnitude under consideration and it has the further advantage: it is good for the brain cells.

One way is to take a ladder structure with major intervals of one foot (300 mm or 30 cm) and smaller intervals of 4 inches (100 mm or 10 cm) to yield a table:

	m			m
			6 ft 5	**1.95**
6 ft 3	**1.90**			
			6 ft 1	1.85
5 ft 11	1.80			
			5 ft 9	1.75
5 ft 7	1.70			
			5 ft 5	**1.65**
5 ft 3	**1.60**			

Starting point: 6 and 3 are 9. *So, 6 ft. 3 is one-ninety.*
And 5 ft. 3 is one-sixty.

Height-squared

Height-squared is used to calculate the Body Mass Index. It is obviously a constant for each adult individual (but not indefinitely over the years).

Height	m	1.50	1.60	1.70	1.80	1.90
$Height^2$	m^2	2.25	2.56	2.89	3.24	3.61

Your "height-squared" could be called your *height factor* (HF).

Body Mass Index

The Body Mass Index (BMI) is body mass divided by height-squared. It has the units kg per m^2, infrequently stated.

BMI = BM / Height-squared = BM / HF

Body mass	Height	Height-squared	BMI
100 kg	2.0 m	4.0 m^2	100/4 = 25

The BMI has come into widespread use over the recent past as an indicator for health - basically, risks to health increase as BMI reaches 25 and above.

20 - 22 is ideal   25+ is overweight   30+ is clinically obese.

The BMI is a general proxy for body fat: outside a range from BMI 18.5 to BMI 25, health hazards develop; that range might be described as *lean-normal* to *fat-normal*.

The basic message is that for both women and men, fat is good; it is an essential means of energy storage.

Too little is bad – you do not have enough stored energy (low fat threshold, BMI 18.5).

Too much is bad – you have excess stored energy (high fat threshold, BMI 25).

For more information, see:

U.S. National Heart, Lung and Blood Institute:

What are Overweight and Obesity?

World Health Organization:

Obesity and overweight

Height Factor - a reinterpretation

Accepting the BMI as your general guideline for health, a further tool in managing your body mass may be devised by rearranging the BMI formula, i.e. the HF may be reinterpreted:

BM = HF x BMI

This arrangement states that your body mass equals your height factor times your body mass index.

This formulation will enable you to check particular body mass values at specific BMI points.

If your height factor is 3, at BMI 20 your body mass is 3 x 20 or 60 kg.

Body Mass Threshold Points

For a specific height factor, which is a constant for an individual, the threshold or transition body masses will be determined, i.e. the particular values at which you will cross from *fat-normal* to *high-fat* and *high-fat* to *obese*.

If your height factor is three, the threshold at which you will cross from fat-normal to high-fat is 3 x 25 or 75 kg (BMI 25) and 3 x 30 or 90 kg (BMI 30) from high-fat to obese.

The digits after the decimal point are significant: at BMI 30, threshold body mass changes by three kilograms for a height factor change of 0.1.
Check / note your body mass for BMI 25 and BMI 30.

BMI Unit change

A second rearrangement states that your height factor is the ratio of your body mass to your body mass index:

HF = BM / BMI

That is, your height factor is numerically the required change in your body mass to yield unit change in your body mass index.

For example, with HF = 3 it requires a decrease in body mass of 3 kg to reduce BMI by one.

If your height factor is 3, it will require a fall of three kilograms to reduce your body mass index from 25 to 24.

The intervals between thresholds are quite large: for the same example, there is a body mass change of 15 kg between BMI 30 and BMI 25.

A quick guide to the good zone

A quick guide to body mass limits to keep you in the good zone lies in your height: the last two digits of your height in metres contains a hidden guide.

If your height is 1.60 m, then your body mass should not be greater than 60 kg. Your BMI will be 23.4, well under your high-fat threshold point.

BMI
A quick guide to the good zone

Height m	**BM** kg	**BMI** kg/m^2	**10% less**
1.95	95	25.0	22.5
1.90	90	24.9	22.4
1.85	85	24.8	22.4
1.80	80	24.7	22.2
1.75	75	24.5	22.0
1.70	70	24.2	21.8
1.65	65	23.9	21.5
1.60	60	23.4	21.1
1.55	55	22.9	20.6

If your height is 1.75 m, then your body mass should not be greater than 75 kg. Your BMI will be 24.5, just under your high-fat threshold point.

Reducing your body mass by a further 10% brings the BMI into the ideal zone of 20-22.

Body Fat

Although the BMI is used as a body fat measure, there is a very large variability of fat level with BMI on an individual basis.

BMI has the advantage that it is easily determined, unlike direct evaluation of body fat. Some bathroom scales measure fat using electrical impedance but are not regarded as very accurate.

For an individual, BMI is not an absolute indicator: one could be a weightlifter with a BMI of 30+ and not be obese. Athletes are in a different category and sumo wrestlers in another.

The BMI continues to be a reasonable indicator for most individuals; the experts will debate the finer points.

In general, for men in their middle years (say, 40 to 60) the statistical picture indicates that body fat percentage is approximately equal to BMI: a man of 50 years with a BMI of 24 could be expected to have 24% body fat.

Younger men have higher *lean body mass* and lower body fat: a young man of 25 with a BMI of 24 could be expected to have 18% body fat (BMI - 6%).

Lean body mass: body mass less mass of body fat.

Older men tend to have lower lean body mass and higher body fat: a man of 75 with a BMI of 24 could be expected to have 30% body fat (BMI + 6%).

For women, add 10% to these figures for an estimate of their body fat percentage.

A good question: what was your body mass and BMI when you were 22?
Probably a BMI of 22 or less for many people.

Where are you on the global fat scale?

The BBC and the London School of Hygiene and Tropical Medicine have developed a calculator to provide the answer:

A man
1.75 m, 75 kg, 45 years

At BMI 24, you have a lower BMI than 84% of males aged 45-59 in the United States, 83% in the UK and 52% in the world.

A woman
1.65 m, 65 kg, 30 years

At BMI 24, you have a lower BMI than 84% of females aged 30-44 in the United States, 73% in the UK and 50% in the world.

Your Olympic athlete body match

A BBC survey of all of the GB team plus 10% of all the other athletes at the London 2012 Olympics. Some of the extremes:

		Athlete	Sport		BMI
Men	Largest	Ricardo Blas, Jr.	Judo	1.85 m 218 kg	63.7
	Smallest	Mohamed Abduh Bakhet	Marathon	1.55 m 50 kg	20.8
Women	Largest	Elisa Casanova	Water Polo	1.85 m 100 kg	29.2
	Smallest	Asuka Teramoto	Gymnastics	1.36 m 30 kg	16.2

Body profile: Waist-hip ratio

The distribution of fat is also considered important. According to the U.S. National Institute of Health, NHLBI guidelines:

> **NHLBI**
>
> Physicians are also advised to determine waist circumference, which is strongly associated with abdominal fat. Excess abdominal fat is an independent predictor of disease risk.
>
> A waist circumference of over 40 inches in men and over 35 inches in women signifies increased risk in those who have a BMI of 25 to 34.9.

Say, one metre for men and 10% less (0.9 m) for women.

A glance at a waistline is generally a good guide to an individual's likely BMI.

There are other claims that waist-hip ratio is a better measure: 0.9 for men and 0.7 for women.

You'll be glad to know that the latter ratio in women, or lower, is considered to be attractive.

More about BMI +

More information on the web, in particular the overview on body mass index in Wikipedia with some details on reservations about its use.

Energy in - Food

Count your joules: evaluating energy input

Energy Input - Diet

Most people are aware that the energy input from food is determined in general by the amount of food consumed.

However, its determination is much more complicated than, say, for a vehicle which consumes just a single fuel, generally gasoline (petrol) or diesel. The fuel for humans comprises thousands of different types with varying energy content.

Consequently, food energy input has to be evaluated by measuring the quantity of each food item consumed, in grams, and multiplying by its energy content per gram.

The procedure is to analyse in detail your actual input. The question transforms to: what exactly do you eat?

Listing what you actually eat is instructive in itself and can be an eye-opener: one can delude oneself about consuming a balanced diet.

Standard Daily Amount of Energy (SDA) – ten megajoules (10 MJ)

Instead of directly using the kilojoule as the food energy unit, utilising a reference number – a standard daily amount of energy – makes for an easier method of evaluation of food energy content.

The Standard Daily Amount of Energy (SDA) already proposed is 10000 kJ or 10 MJ; it corresponds to the traditional guideline daily amount of 2500 kcal for the average adult male.

In percentage terms, 100% SDA is 100 00 kJ and 1% SDA is 100 kJ. All food energy inputs are expressed in terms of percentages, e.g. a yogurt serving is 4% SDA, meaning it has an energy content of 400 kJ.

Thus, a simple procedure is to work in percentages which is an intuitive measure for most people.

Energy Content

The energy content of individual foods is **calculated** on the basis of their composition: **fat**, **protein** and **carbohydrate** are the main energy contributors.

The energy factors used by manufacturers in calculating the energy content, as well as the way food labels are presented, are regulated by the various jurisdictions.

In the EU the energy factors in SI units are:

Fat: 37 kJ/g   **Protein: 17 kJ/g**   **Carbohydrate: 17 kJ/g**

Notably, the contribution of fat is more than twice that of protein and carbohydrate, which are identical.

From 2008, **fibre** has been added to the list of energy contributors with an energy content of **8 kJ/g**.

Food Energy Information: Packaging

European Union

As previously described, the combined energy contribution from the nutrients is presented on a per 100 g basis and per serving for the food product.

For example, the energy content of the cereal illustrated is presented:

Typical value per 100 g 1604 kJ 378 kcal

The energy content is sixteen hundred and four kilojoules per 100 g which translates readily to **16% SDA per 100 g**. The calculation:

100 g	g	kJ/g	kJ
Protein	7	17	119
Carbohydrate	84	17	1428
Fat	0.9	37	33
Fibre	3	8	24
			1604

The energy content per **serving** is also listed (30 g of cornflakes with 125 millilitres of semi-skimmed milk, **732 kJ**).
This energy content reads as 7.3% SDA or **7% SDA** rounded off.

Rounding-off should be your usual practise – higher precision is not justified. Variation in analyses / calculation procedure will result in different values of energy content.
For example, prior to 2008 the energy content of the cereal example was displayed as 1580 kJ per 100 g.
A calculation using factors in kcal/g *(*4, 4, 9, 2 kcal/g*) yields* 378 kcal per 100 g *or* 1582 kJ per 100 g *on conversion.*

For more information on EU nutrition labelling, see overview by the Food Safety Authority of Ireland.

United States

As previously illustrated, US food packaging displays only energy per serving, in “Calories”.

A serving of cornflakes (1 Cup; 28 g) is 100 “Calories”.

Amount Per Serving	Cereal	With ½ cup skim milk
Calories	100	140

The energy content is readily converted to % SDA by multiplying the "Calories" figure (in hundreds) by four to yield:

Cereal	**4% SDA**	
Cereal + milk	**5.6% SDA**	(6% SDA rounded off)

For more on US labeling practise, see:
US FDA Labeling & Nutrition

Food Energy Information: Web databases

European Union

If there is no information on the package or there is no packaging, as often with fruit and vegetables, a very good source is the Danish food information website:

Technical University of Denmark: National Food Institute

Danish data for cornflakes are shown here for comparison:

Cornflakes, average values

Content pr. 100 g	Unit	Content	Variation	No.	Source
Energy	kJ	1559			00050
Protein, total [NCF: 6.25]	g	7.3	5.3 - 8.1	8	90115
total-N	g	1.2	0.8 - 1.3	8	00050
Fat, total [FACF: 0.930]	g	1.3	0.9 - 1.6	8	90120
saturated fatty acids	g	0.2			00050
monounsaturated fatty acids	g	0.4			00050
polyunsaturated fatty acids	g	0.6			00050
Carbohydrate, total	g	83.2	81.4 - 85.9	5	00160
carbohydrate, available	g	80.1			00050
added sugar	g	5.0			00050
dietary fibre	g	3.1	2.0 - 4.6	6	90107
Alcohol	g	0			00000
Ash	g	2.6	1.8 - 3.5	8	90115
Moisture	g	5.0	4.0 - 6.9	8	90115

The energy content of the cornflakes is 15.6% SDA per 100 g.
Moisture and ash are explicitly stated as well as alcohol (energy factor: 29 kJ/g).
Particularly of value is the listing of sugar added to the base product.
NCF: nitrogen to protein conversion factor.
FACF: fatty acid conversion factor.
No.: number of samples.

United States

A comprehensive database of 8500 US foods, many of which are global brands (there may be local compositional differences) is that of the US Department of Agriculture:

USDA National Nutrient Database

The entry for a food product consists of a "Basic Report", a more detailed "Full Report" and a "Statistics Report".

The following shows an excerpt from the Basic Report for the cereal example:

Basic Report

Nutrient data for 08020, Cereals ready-to-eat, KELLOGG, KELLOGG'S Corn Flakes

Return to Search Results   Full Report (All Nutrients)   Statistics Report

Nutrient values and weights are for edible portion

Nutrient	Unit	Value per 100.0g	cup (1 NLEA serving) 28g
Proximates			
Water	g	3.76	1.05
Energy	kcal	357	100
Protein	g	7.50	2.10
Total lipid (fat)	g	0.40	0.11
Carbohydrate, by difference	g	84.10	23.55
Fiber, total dietary	g	3.3	0.9
Sugars, total	g	9.50	2.66

"Proximates" refers to an (ap)proximate analysis where only major constituents are listed, as distinct from an ultimate analysis.
NLEA: Nutrition Labeling and Education Act.

The energy content is obtained using a standard calculation procedure with energy factors in kcal/g:

100 g	g	kcal/g	kcal
Protein	7.5	4	30
Total lipid (fat)	0.4	9	3.6
Carbohydrate (less fiber)	80.8	4	323.2
			356.8

The Full Report lists the energy content as 1494 kJ/100 g.
(from kcal using the standard conversion factor of 4.184 kJ/kcal.*)*

Supermarkets

Some supermarkets have website nutritional information on the extensive range of products they offer; for example, the multinational **Tesco** .

Walmart provide nutritional information in standard U.S. labelling format for many of their products.

Fast food

Fast food is widely available and widely availed of. Nutritional information is accessible on the the websites of the larger chains and is generally applicable for similar products.

A general website fastfood presents nutritional information and a menu calculator for fast food chains and restaurants in the US.

McDonalds have an interesting website which shows nutrition data in two formats – product picture and spreadsheet – as well as a menu calculator.

*The range of the main product – the hamburger – extends from the basic burger (*100 g, 10% SDA, 1 MJ*) without cheese, through ten variations with cheese, including the "Big Mac" (*215 g, 23% SDA*) and the heavy hitter, the "Double Quarter Pounder with Cheese" (*283 g, 31% SDA*).*

Alcohol

Alcohol for human consumption (*ethanol*) has a high energy factor of 29 kJ/g; it is about 20% less than the standard value for fats and oils but 70% more than that for carbohydrate and protein.

From spirits to wine to beer to sweet/cream liqueurs, the energy content of alcoholic beverages shows an increasing contribution from carbohydrate, to a much lesser extent protein, and then fat.

Alcoholic beverages sold in bottle or container are required to have the alcohol content by volume on the label; regrettably, there is no requirement to display nutritional information such as the energy content per serving.

Indicative energy content for typical servings:

	Spirits	**Wine**	**Liqueur**	**Beer**		
Alcohol % vol	40	13.5	20	4.5		
Serving	50 mL	150 mL	50 mL	330 mL	500 mL	568 mL
Alcohol mL	20	20	10	15	22.5	25.5
% SDA	**5**	**5**	**5**	**5**	**8**	**9**

US: 1 fl oz: ~30 ml UK: alcohol "unit": 10 mL; 568 mL: a *pint*

More information from producers, and the databases:

DTU Beverages **USDA Beverages**

Current Energy Input Evaluation of Diet

With the energy content conveniently available and in an understandable format, what's the next step?

First to look at are your typical everyday meals: typical breakfast, typical lunch and so on. Write it down or type it out.

For most people there is not a large variation from day to day and one could list a dietary input which is maybe valid six days out of seven.

If you want to determine your current energy input with a reasonable accuracy, you have to measure the amount of each food item you consume.

List everything and measure everything. There is no need to make any volume measurements – with your new kitchen scales on the counter, all quantities can be measured in grams.

Agreed, the process is tedious but you only have to do it once to get a good estimate.
And it all does not have to be done on the one day: First session, a breakfast audit. Another day, midday meals. And so on.
After a week or two, you will have a complete picture of what actually is going on.

Meals at home are readily measured; those outside not so easy. Take a photo; make an estimate.

The end of the process is to produce a number which represents the typical, daily energy input on average.

Breakfast

For example, a typical breakfast might be (numbers rounded off):

Breakfast	Serving g	% SDA per 100 g	% SDA per serving
Orange	110	2	2
Mixed Cereal	40	15	6
Milk	100	2	2
Toast	40	10	4
Butter	5	35	2
Marmalade	15	11	2
Coffee	200	0	0
Milk	10	2	0
Sugar	5	17	1
Total			**19**

Calculation for sugar: 5 x 17/100 = 0.85% or 1 % rounded off.

The total amount of food consumed for breakfast, in liquids and solids, was 515 g and the energy contribution was 19% SDA.

If you wished to reduce breakfast contribution to ~10%, one option would be to eliminate toast and its fellow travellers, butter and marmalade.

Evening

An evening meal might look like:

Evening	Serving g	% SDA per 100 g	% SDA
Lasagna	300	6.5	20
Mixed Salad	150	2	3
Glass of wine	150	3	5
Dessert	100	10	10
Coffee +	200		1
Total			**39**

Coffee + is coffee with milk and sugar.

In many cases, the energy content per serving will already be available and a figure per 100 g is unnecessary.

Your typical mid-day meal is appraised in a similar fashion and it is very important not to omit the "**Other**" category: those mid-morning, mid-afternoon or late evening snacks, e.g. a can of Xtra-Cola delivers 6% SDA and is very easily consumed.

For the typical day one might end up with a distribution as follows:

Breakfast 19% Midday 24% Evening 39% Other 10%

<u>**Total 92% SDA**</u>

Celebration meals & social events

A "celebration" meal at weekends at home, or at a restaurant, may easily reach 60% SDA when all the extras are considered: drinks, snacks, starters and more.
The problem is not that a single meal constitutes a very large energy input, but that there are too many of them – you are celebrating too many times per week.

Entertainment events must also be included, of course: visits to the pub as well as to sport events and to cinemas, where part of the entertainment is eating something.

Other “dangerously” high energy events are business meals, hotel buffet breakfasts, receptions and so on. Scrutinise them closely.

Average daily input

The average daily intake over the week must include the extra amount from celebration events, social events and so on.

The celebration meal mentioned (60% SDA) exceeds the typical evening meal (39% SDA) by 21% SDA. If there are, for example, generally two of these meals per week, the total excess is 42% or 6% SDA if divided by seven to give an average daily extra amount.

If the energy intake on a single event out socialising amounts to 28% SDA, say, the average is 4% SDA over the seven days.

In summary:

Over a week	% SDA
Breakfast	19
Mid-day	24
Evening	39
Other	10
Typical day	92
Extra:	
Celebration meals av.	6
Social events av.	4
Total	**102**

The average daily intake of food energy is 102% SDA or just over 10 MJ.

It is not critically important that this assessment is highly precise but it should represent a frank and honest best estimate of your current food energy intake.

What is important is that any change you make to your diet is clearly identified and quantified, and is not some wishy-washy statement about less of this or that or the other.

Specifically, if you have decided that you are going to reduce your food energy input by 10% SDA on average, you must be able to point to the elimination / change of particular food items that achieve this.

Toast with butter and marmalade is no longer on my breakfast menu.
Having cookies / biscuits at my coffee break on a diet day is a no-no.

Energy Out

Work out +

Yes! The doctor said exercise more.

Another audit? Yes!

What exactly is your daily routine?

But first there are some SI preliminaries that have to do with your movement: velocity, acceleration, force, work, energy and power.

Tedious, yes! But there is a rapid pay off.

*Skip to **Application** and have a look!*

Movement

Every movement you make is made up of an acceleration period to reach some maximum velocity, followed by a deceleration to zero velocity.

For example, reach for that cup of coffee!

Each acceleration / deceleration requires a force to be exerted by you, by your built-in motors – your muscles.
What are these forces?

You might recall from school physics (courtesy of Sir Isaac Newton) that:

force equals mass multiplied by acceleration

If you know the acceleration, you can determine the force.

The acceleration most well-known to us is Earth's gravitational acceleration, a constant feature of the physical reality in which we live and in which we have evolved.

A standard value for this acceleration is 9.81 metres per second, per second, i.e. an increase of speed or velocity of approximately 10 m/s, every second, by a falling object.

Force

In the International System of Units, the unit of force is the *newton* (N), named after Sir Isaac.

Numerically, the earth's gravitational force on you – your "Earth-force" or "Earth-weight" – is simply ten times your body mass.

If your body mass is 65 kg*, your Earth-weight is 650 newtons.*

Work and Energy

To complete the preliminaries and to demonstrate one of the great advantages of the SI, the basic definitions of **work** and **energy** need to be considered.

We all know what work means – it means some effort has to be made to accomplish a task, maybe pleasant, maybe unpleasant.

In physics, it means some force has to be exerted and moved through some distance. This leads to a definition:

work = force x distance

One unit of work is done when one unit of force moves through one unit of distance.

The unit of force is the *newton,* the unit of distance is the *metre* and the unit of work is the *joule*.

One joule (symbol, J; named after James Joule, a nineteenth century English physicist) equals one newton-metre (N m).

The joule: the unit of work, is the unit of energy

The word "energy" comes from Greek *en* meaning in and *erg* meaning work i.e. capable of work.

Energy has different forms, such as mechanical, electrical, thermal, chemical, nuclear; energy may be converted from one form into another, but no energy disappears in any conversion process.

As in money matters, an energy balance can always be made for a process, with the caveat that in the accounting procedure, all forms of energy involved in the process must be identified.

In the SI, in all forms, it has the same unit: the joule.

The joule is the unit of the energy content of food, of energy input; it is the unit of the energy stored in the human body either thermally, or by way of fat or by other means; it is the unit of heat loss and of work and exercise, of energy output.

Application: Climbing the Stairs

The application is immediate:

One of the most energy demanding activities you can undertake is going up the stairs.

Why? Because you have to exert a large force in lifting your total clothed body mass through the elevation change.

You are doing very significant work:

WORK

Climbing the stairs

If your clothed body mass is 70 kg,
your Earth-force will be 70 x 10 or 700 newtons.

If the height between floors is 3 m, then,
the work done by you in lifting yourself through 3 m is,
force by distance: 700 N x 3 m = 2100 N m.

2100 newton-metres is 2100 joules or 2.1 kilojoules

The work required to lift one kilogram one metre,
is numerically equal to
the planet's gravitational acceleration.
On Earth it is 10 joules per kilogram-metre.
10 J/kg-m

Consider putting your 10 kg bag in the overhead bin of an aircraft.
Now do six more. Then repeat. It's work!
More: get out of bed; stand up from your chair; raise your 4 kg arm over your head.

Energy source

Where did the energy come from? Not too difficult to answer – ultimately from your food energy input.

Your body's complex processing system plus muscle combination miraculously transformed food energy into stored energy and then into physical work, resulting in the elevation change.

However, in the short term the energy output could be at the expense only of your stored energy and reflected in a decrease in your fat level / body mass.

Efficiency

The efficiency with which this activity is performed (in terms of the ratio of the work output to food energy input) is not high: 20 to 25% at the most.

At 20% efficiency, the required food energy input to climb the stairs is 2.1 kJ x 5 or 10.5 kJ; let's say 10 kJ.

Climb the stairs	Once	10 times	100 times
Food energy kJ	10	100	1000
% SDA	0.1	1	10
Bread g	1	10	100

Check out the size of a gram of bread on your kitchen scales!

If you climb the stairs 10 times throughout the day, that means a food energy demand of 100 kJ or 1% SDA.

If it is 100 times, that means 1000 kJ (1 MJ) or 10% SDA.

But that's just about the slice of toast plus, you had at breakfast! A slice of bread, 40 grams – no butter, no jam, no spread – has an energy content of about 400 kJ.

SOME CONCLUSIONS

It is amazing the amount of physical work that can be obtained from a small quantity of food.

In managing your body mass, it makes more sense to restrict food energy input rather than try to "burn" it off with exercise.

Exercise is to be done for its own sake – your physical well-being, your health.

Power

Power is defined as the rate of energy transfer, or the rate of energy conversion, in joules per second.

Its SI unit is the *watt* (symbol W; named after James Watt, 18th century Scottish engineer). One watt equals one joule per second (1 W = 1 J/s).

If it takes you 15 s to ascend the stairs, that means your power output is 2100 J in 15 s, i.e. 140 joules per second: 140 W.

If you halve the time, you will double the power output to 280 W; however, the energy requirement still remains the same at 2.1 kJ.

Humans (and other animals) are capable of large power outputs, as in a jump, a punch, a tennis stroke, a golf drive or even just standing up – it depends on the time taken for the process.

From a food input point of view, the energy conversion rate is about five times that; your metabolic power is 700 W; it is numerically ten times your clothed body mass.

Asleep: Basal metabolic rate (BMR) / Basal metabolic power

Asleep there is minimal large scale movement – just steady breathing, heart beating. But there are millions of processes taking place internally, one end result of which is your core body temperature is maintained at ~ 37 °C.

Over the sleep period the average energy transfer rate is known as the *basal metabolic rate*: the aggregate power of your body involved in all of those processes.

Basal metabolic rate depends largely on *lean body mass*, i.e. body mass less fat mass. However, there is significant variation between individuals even with the same lean mass.

The high power organs: brain and liver, each about 20% BMR; heart, about 10%.

For the ordinary male (not an athlete, not overweight), an estimate of basal metabolic rate is:

BMR:
one watt per kilogram body mass

If your height is 1.75 m, your body mass 75 kg, your BMR will be about 75 watts.

Women biologically are equipped with more fat tissue and thus a woman of 1.75 m, 75 kg, would have a lower basal metabolic rate – about 10% lower.

Movement / Action

Up and about there are movements and actions of all kinds from blinking to frowning to shivering to fidgeting to walking to lifting to pushing to pulling to swallowing to talking to laughing and many more.

These movements involve accelerations and decelerations and muscular force is required to achieve them.

In addition to elevation changes, they consequently mean work; they mean an energy output and a corresponding food energy input.

Muscle energy is also required to exert static forces on one's surroundings, with little or no movement.

Such actions are in addition to all of the body's internal processes and the overall rate of energy transfer of the complex is the metabolic rate or power, in watts.

Indicative levels of energy output for various activities are shown in the following table as a ratio of metabolic rate to basal metabolic rate (**MR/BMR**).

Example: a 65 kg *woman with a basal metabolic rate of* 60 W.

	Ratio MR BMR	**Woman 65 kg** W	**%SDA** 1 h	**%SDA** 8 h	**%SDA** 24 h
Asleep	1.0	60	2.2	17	52
At rest – reclined	1.2	72	2.6	21	
At rest – seated	1.4	84	3.0	24	
Standing	1.7	102	3.7	29	
Stroll (1 m/s)	2.5	150	5.4	43	
Fast walk (1.5 m/s)	4	240	8.6	69	
Housework	4	240	8.6	69	
Exercise / dancing	5	300	10.8		
Walking up stairs (0.2 m/s vertically)	11	650	23.4		

60 J/s = 216 kJ/h = 2.2 % SDA/h

For more indicative data see:

Human energy requirements
Report of a Joint FAO/WHO/UNU Expert Consultation
Energy Costs of Activities

PAR: physical activity ratio (MR/BMR) for the activity.
PAL: physical activity level – ratio over 24 hours.
Males, surprisingly, are not on the list for house cleaning but they do iron clothes.

Estimate your average physical activity level here.

The sedentary life

To note are the ratios at very low levels of activity: reclining, it is just 20% above being in bed asleep.

Sitting around is an improvement to 40% above basal.

This is the region of the sedentary life. The average for the whole day might be 1.4 times basal.

Benchmark Activity

The recommended minimum activity by various health authorities is a fast walk for half-an-hour per day.

Metabolic rate is about four times basal – 240 W in the example.

The energy demand for the half-hour is 4.3% SDA about 3% SDA more than simply resting for the period.

Once again it highlights the fact that the actual amount of energy is not significant – it is the actual physical exercise and its demand on your cardiovascular system, lungs, muscles, bones, joints i.e. its demand on the body complex, that is important.

The body is a dynamic system that has evolved to deal with the Earth's gravitational force: if one resigns from that contest there are physiological consequences.

For example, there is the obvious loss of muscle mass when a leg has been in a cast inactive for a number of weeks.

And astonishing is the loss of bone mass by astronauts in space flight in the absence of gravitational force – the ultimate in reclining on the couch.

Weightlessness

Studies of cosmonauts and astronauts who spent many months on space station Mir revealed that space travelers can lose (on average) 1 to 2 percent of bone mass each month.

Spacefarers typically experience bone loss in the lower halves of their bodies particularly in the lumbar vertebrae and the leg bones.

NASA Science: Space Bones

Housework

The indicative level for housework is the same as the benchmark but it depends on the housework.

Vigorous activity is what is required: carrying the vacuum cleaner upstairs, moving furniture, pushing, pulling, lifting.

Any housework is good but a bit of “puff” is the essential feature, some sweat on the brow, if it is to enter the benchmark category.

Exercise

Similarly for exercising / dancing – not slow, if undoubtedly graceful, movements around the room.

Include a “work out” period in your dance session.

If sports / gym / pool is your preference, make sure it has some vigorous, not just desultory activity.

Extreme exercise

The extreme exercise illustrated is climbing the stairs at 0.2 m/s vertically or 200 mm/s.

A step rise might typically be 175 mm so the rate is about one step per second. This is slow, but very arduous if you continue for more than a few flights of stairs.

Metabolic power is numerically about 10 times body mass – 650 W for the 65 kg woman, ignoring clothes mass.

Take it easy, in small doses.

Management Focus

Focus

The starting point for management of your body mass is not your food energy input but your energy output.

For your good health you should be active, no matter what age you are.

You have evolved to be active: it is simply not possible to justify an inactivity mode of putting your feet up, reaching for entertainment food and watching TV as your best way, for the physical you, of spending the day.

The overall objective is your good health. If you accept that your health is important, that it is worth doing something about, then the logic is you do that something.

Make an audit of your activity throughout the day. If you have no period during the day of some vigorous physical work / exercise, you have a shortfall.

People who have physically active jobs, moving on their feet for much of the day, are unlikely to have a problem.

People who like active engagement in sport, rather than looking at others engaging in sport, are also less likely to have a shortfall.

The big problem area is that very large group from young to old who are sedentary for much of the day.

It comes as a bit of a surprise to realise that in education, the students are in sedentary occupations; the teacher or lecturer is the only one moving about.

The specification of that minimum physical work is very flexible: it can be as little as half-an-hour vigorous walk – not a stroll at 1 m/s – per day.

It is cumulative: it can be broken into shorter sessions.

It can be diverse – simple exercises, dancing, housework, gardening, stairs climbing.

For those who are not enamoured of gyms or any form of organised activity, this flexibility is a gift.

But it also means there is no excuse.

If you subscribe to three square meals per day, what about giving equal importance to three "square" exercise periods per day? Short and sharp. Say:

mid-morning
mid-afternoon
mid-evening

Fair and square!

Mid-morning and mid-afternoon, as a regular routine, take the scenic route via several flights of stairs to that rest-room / toilet which is most distant from your office.

Most distant? Be reasonable!

Mid-evening, it may find a natural expression in some housework – there's always something that needs to be done.

If that is too boring, try some exercises and include a few flights of stairs.

General Physical Activity

In addition to achieving your minimum benchmark activity, it is desirable to move your general physical activity up a notch, in a phrase:

spend more time on your feet

Stand up, walk around; take / make your phone calls on your feet.

Check desk exercise routines on the web or devise your own. Start with a single exercise and build it into your routine.

Take your breaks and some of your meals standing up; there is no need sit down if you have already been sitting for hours at your desk or at a meeting.

Get off the couch, move about, stretch a bit; and don't forget the long-haul flights

For more views about spending time on your feet:

Calorie Burner: How much better is standing up than sitting?

A Summary View

	A Woman		**A Man**	
Height	1.65 m		1.75 m	
Body mass	65 kg		75 kg	
Body Mass Index	23.9		24.5	
Height Factor	2.72		3.06	
Overweight Threshold	68 kg		77 kg	
Obesity Threshold	82 kg		92 kg	
Body Fat %	34		24	
Fat mass	16 kg		18 kg	
Lean body mass	49 kg		57 kg	
Basal metabolic rate W	60	1.0	75	
% SDA	52	1.0	65	
MJ/d	5.2	1.0	6.5	
Daily Energy Demand				
Very inactive % SDA	60	1.2	75	
Active	80	1.5	100	
Very active	100	1.9	125	
Very inactive MJ/d	6	1.2	7.5	
Active	8	1.5	10	
Very active	10	1.9	12.5	
Very inactive W (av.)	72	1.2	90	
Active	80	1.5	113	
Very active	114	1.9	143	

Act / Move – More information:

American Heart Association	Get Moving!
British Heart Foundation	Staying active
Irish Heart Foundation	Be Active
Harvard School of Public Health	Staying Active
National Heart, Lung and Blood Institute	Physical Activity and Your Heart
World Health Organization	Physical Activity for Health

Targets

Modest, but relentless

For most people interested in developing and implementing a program of management, it is probable that reducing body mass is their concern:

They would like to reach some some BMI value in the healthy zone below BMI 25.

The overall objective is your good health: this means a permanent, sustainable balance between your energy output in work and exercise, your dietary energy input, and a stored energy level which places you in the good zone.

To achieve this you should set targets in each area, which are not ambitious but, by contrast, you are relentless in implementing your program to reach them.

Losing Body Mass

As usually understood, loss of body mass means a decrease of fat level – a decrease in energy stored. For most of us, it does not mean a loss of muscle mass, loss of bone mass or water loss (either by temporary dehydration or changing water balances).

If your body mass is stable, irrespective of your particular body mass index, there exists a balance between input energy and output energy – there is an equilibrium.

The only way to achieve this loss is to disturb the equilibrium: reduce current energy input or increase energy output or combine both (exceptionally, fat may be surgically removed).

However, changing energy inputs / outputs will change body mass in a complex response that is very much an individual one.

First, adipose tissue is not an inert store that one carries around in various body depots – it is a dynamic web of cells that interacts with the rest of the body and can vary as, for example, that around the waist which presents a higher risk profile to health.

Muscle mass will be affected in the change process as, in the first instance, one has less total mass to carry around and lift up stairs; changes in activity level may not compensate.

Basal metabolic rate will change; water mass will also be affected as the body adjusts to a new equilibrium regime.

The following is a very general, simplified outline of what is involved:

Losing one kilogram

To lose one kilogram, means that the associated stored energy content must be utilised as part of the daily input.

Fat has an energy content of 37% SDA per 100 g; however, it is stored in the body as adipose (fatty) tissue, whose energy content is ca. 30% SDA per 100 g (3.0 MJ/100 g).

Multiplied by 10 yields the energy content of one thousand grams or 1 kg of fatty tissue.

That energy amount is 300% SDA (30 MJ); it is probably the total energy needs of many people for four days.

Lean tissue, on the other hand, has a much smaller fraction of the energy density of adipose tissue and is very much more sensitive to any energy demand on it.

For a given energy demand, your lean mass will show a very much larger change than your mass of stored fat, your principal energy reserve.

For a detailed discussion of the issues involved, see the paper by K. D. Hall et al.:

Energy balance and its components: implications for bodyweight regulation.

Losing one kilogram per month

Assuming by way of illustration a loss of adipose tissue only, it will require an average reduction of 10% SDA each day in energy input if the target period to lose one kilogram is one month (300% SDA divided by 30).

Any part of this energy demand that is met at the expense of tissue other than adipose, will result in a greater loss of body mass in the month or require a shorter period to lose one kilogram.

Allowing one free day per week, means a reduction of 10 x 7/6 or 11.7% SDA on each "diet day". Let's say 12%.

12% SDA reduction per day is a modest amount:

Taking the example illustrated previously, the reduction of energy input from 102% to 90% of SDA should not be enormously difficult.

It does not necessarily mean a reduction in the quantity of food you consume each day – it is a reduction in the energy content, very probably achieved in a review of the composition of your diet.

Alternatively, there could be 10% reduction in input and 2% increase in energy output or any mix of the two.

Probably the best route is to aim for the 12% reduction in diet and have increased output take care of any slippage.

Some qualifications

As stated above, this is a very simplified approach: when body mass decreases energy output is reduced and consequently, less energy needs to be drawn from your energy stores – what might be true at the start of the month will not be true at the end; reduction of body mass will not continue on a straight-line basis.

Taking body response into account, it is estimated that an average 10% SDA per day reduction in food energy input will ultimately result in a 10 kg reduction in body mass, while maintaining the same physical activity level:

1 kg change in body mass
per
1% SDA change in diet

For a specific individual, the likely progress of reduction of body mass will be on a constant percentage basis, after your system's initial responses have settled down.

If you have lost some fraction of your target body mass reduction in, say, the first month of your program, a best estimate is that it is likely to be maintained in the following month.

You are one month into your program.
Your target fall is 10 kg *(*10% SDA *reduction).*
Your body mass has fallen by 1 kg *in the month,* 10% *of total.*
Likely progress: 10% *of remaining total each month.*
Second month: 10% *of* 9 kg *or* 0.9 kg.
Third month: 10% of 8.1 kg or 0.8 kg.
Cumulative fall over the three months: 2.7 kg.

See panel on a Computer Simulation for more exploration of your likely progress.

Practical positives

From a practical management point of view, your focus must be on an absolute reduction of body mass to bring your body mass index into the good zone.

How physiologically one's body responds in detail is information that is not normally available to us.

And how your body mass will respond over time, even with strict attention to your program, is not predictable with any certainty.

All of interest, yes, but the broad measures of BMI, increased physical activity and a balanced diet are the crucial ones for your attention.

Computer Simulation

A sophisticated analysis of what you might expect is provided by a simulator developed by the US NIDDH (National Institute of Diabetes Digestion and Kidney Diseases).

It provides an estimate based on data from US sample populations; remember that your response is still very much an individual one.

The following shows the results for a woman and a man, both aged 40, targeting a body mass loss of six kilograms in a six month's program:

	A Woman		**A Man**
Height	**1.65 m**		**1.75 m**
Start of Program			
Body mass	**72 kg**		**81 kg**
Body Mass Index	**26.4**		**26.4**
Body Fat %	34.5		23.9
Fat mass	25 kg		19 kg
Activity level: Sedentary	1.4		1.4
End: Target loss of 6 kg			
Body mass	**66.4 kg**		**75.3 kg**
Body Mass Index	**24.4**		**24.6**
Body Fat %	31.8		21.1
Fat mass	21 kg		16 kg
Activity level: No change	1.4		1.4
Diet	% SDA per day		% SDA per day
Current	82		100
Program	67		86
Reduction	14		14
Post-Program Maintenance	77		95

The simulation estimates that a dietary reduction of 14 % SDA from current level, for both the man and the woman, will result in an average body mass loss of about one kilogram per month over the six months – without any change in activity level.

For the woman the body mass loss comprises 3.7 kg of fat and 1.9 kg of lean body mass. For the man the loss comprises 3.5 kg of fat mass and 2.2 kg of lean mass.

The simulation also shows the required maintenance level diets following the program: these are adjusted upwards to 77% SDA and 95% SDA, just 5% below the initial levels.

This obviously requires a deliberate change of course: the subjects have to start eating more, otherwise their body mass would continue to fall. It shows the potential for a further reduction if desired.

Losing two kilograms per month

Doubling target body mass loss from one kilogram to two kilograms per month means a doubling of the reduction from 12% to 24% SDA per day (same assumptions).

This, however, is a radical and demanding change: it is much preferable to set a modest target and achieve it than fail on more ambitious goals – your long term objective is more likely to be realised.

As indicated in the Computer Simulation panel, there will be an opportunity for an appraisal at the end of, say, six months and one can then decide on a course adjustment which could be a further reduction in body mass.

Targets & Exercise

From the very first days of your program, you should be meeting the minimum recommended amount of exercise / physical work each day – there is no excuse for not doing so.

You're not! You're skipping some days! Who's in charge here?

Build it in as a permanent feature of your life, an essential to your physical well-being. There must be a shock-horror reaction if you miss out on your daily exercise / work periods.

Increased physical activity, increased output, will obviously reduce the time to reach your target body mass for the same reduction in food energy input.

Targets & Diet

Besides requiring a simple decision on reduction in food energy input, the start of the program presents an opportunity to appraise one's diet in light of well established principles: generally eat a broad based diet.

Consume more vegetables and fruit, add no sugar, minimise saturated fat, increase oily fish intake, limit alcohol.
You'll feel better.

More information – see, for example, the Harvard School of Public Health:
Healthy Eating Plate

Having the whole picture of your actual energy input, incorporating any revision in its make-up, you can then decide on the amount to reduce on a permanent, sustainable basis.

Be smart! Take it slowly, without let up.

However, on the seventh day it is time out!

And any later course adjustment is something to look forward to in either a revised diet upwards, or "bankable" in a greater flexibility and more days out.

Specific Program Targets

1. Reduce your body mass by one kilogram.
   Psychologically, a very important first step.

2. Reduce your body mass index by one.
   Another important step – you are making great progress.

3. Break through the BMI 30 / 25 threshold.
   A MAJOR EVENT – celebrate with a day out.

4. Continue the reduction in unit steps of BMI.
   Slowly, but relentlessly.

5. Reach your target BMI.
   THE MAJOR EVENT – time to celebrate!

Timetable

Your timetable will depend on the program but a target loss of one kilogram per month is reasonable and attainable.

However, be patient. The actual magnitude of your achievement each month is not critical; what is important is that you maintain progress.

Remember, the objective is to obtain a sustainable, permanent change.

Finally, once you reach your target body mass and equilibrium, remember to maintain your regular scrutiny of your bathroom scales.
This will make possible an early intervention and course correction should a dreaded drift have occurred.

The International System of Units

SI Units

> **"… a single practical system of units of measurement suitable for adoption by all countries …"**
>
> From Resolution 6 of the 9th CGPM, 1948

The International System of Units is called SI after the French title, *Systéme Internationale d'Unités*. This system of units has been established, and is modified from time to time, by an international body called **Conference Generale des Poids et Mesures (CGPM)**.

It has an executive arm – Bureau International des Poids et Mesures (BIPM) – which was established in 1875 and is located in Paris. It has 54 member states which support its operations.

The US was an original member of the convention setting up BIPM while the UK joined nine years later.

Units

SI units comprise base units and derived units.

SI base units are the well-known ones of **kilogram** (symbol, kg), **second** (s) and **metre** (m), for the physical quantities **mass**, **time** and **length**.

In the US, standard spelling is "meter".

In addition, there are four other base units: thermodynamic temperature, electrical current, amount of substance and luminous intensity.

Derived units are constructed from the base units, e.g. velocity, in metres per second (m/s).

The whole structure of science and engineering is built on the seven base units. All other units can be reduced to a combination of these units.

Mass

The kilogram is the unit of mass in the International System of Units. It was originally conceived as the mass of a litre of water at maximum density (4 °C).

In the US, standard spelling is "liter".
Density is mass per unit volume.

Following a decision of the French National Assembly in 1791, a physical standard in the form of a platinum prototype of the kilogram was produced and was held in Paris from 1799.

Nearly a hundred years later in 1889, the **1st Conference Generale des Poids et Mesures** adopted a technically new standard, copies of which were distributed among the standards laboratories of the member countries.

The international prototype of the kilogram

In 1901, because of the continuing ambiguity between mass and "weight", the **3rd Conference Generale** took steps to eliminate the confusion. It declared:

1. The kilogram is the unit of mass; it is equal to the mass of the international prototype of the kilogram;

2. The word "weight" denotes a quantity of the same nature as a "force": the weight of a body is the product of its mass and the acceleration due to gravity;

Mass / density is a characteristic or property of matter; weight is a gravitational force.

The physical reality of our world is that masses exert force on each other; this is most immediately observed in the gravitational force of planet Earth on us – we call this force "weight".

Mass is physically sensed by us as a force necessary to move something or lift something. That something includes ourselves.

Planet Earth's gravitational force on one kilogram is 2.2046 pounds.
Alternatively, one kilogram weighs 2.2046 pounds on planet Earth.

Time

In 1889, the unit of time, the second, was defined astronomically such that there were 86400 seconds in the mean period of rotation of the earth, the "mean solar day".

60 s *per minute; 60 minutes per hour; 24 hours per day: 60 x 60 x 24 = 86400 seconds.*

Because of variations in the length of the mean solar day, the second was redefined in 1968 in terms of a fixed physical phenomenon: atomic radiation.

Specifically, the second is now the duration of 9.192631770 gigacycles (billion cycles) of electromagnetic radiation emitted by the caesium atom.

What about the hour, the minute and so on?

In 1996, a limited number of <u>non-SI</u> time units,

the <u>minute</u> (min) **the <u>hour</u> (h)** **the <u>day</u> (d)**

were accepted for use with the SI.

Length

The metre (m) was originally defined by the French Academy of Science in 1791 as one ten-millionth of the distance from the North Pole to the equator along the meridian passing through Paris.

In 1799 this definition was realised in a practical way in the form of a platinum bar.
In 1889, as with the kilogram, it was replaced by a technically improved standard, a platinum-iridium bar of special construction with marks identifying the length.

More recently, with the development of technology, a different approach has been adopted:
Since the velocity of light is regarded as a universal constant, it was defined as 299 792 458 m/s.
Accordingly, in 1983, the metre length was fixed as the distance travelled by light in vacuum in 1/299 792 458 of a second.

A memorable number is the velocity of light:
it is 300 million metres per second
(300 megametres per second; 300 Mm/s)
accurate enough for your calculations in those quiet moments.
Just over a second to the moon; 500 seconds to the sun.

Length: English to metric

In conversion to metric, the starting point is:

one inch equals 25.4 millimetres exactly

This results in the metre being equal to 39.37 inches, but not exactly. Various conversion factors are as follows, with exact values shown in bold.

SI	**1 Inch**	**1 Foot**	**1 Yard**	**1 Mile**	**1 Nautical Mile***
millimetres	**25.4**	**304.8**	**914.4**		
metres		**0.3048**	0.914	1609.3	**1852**
kilometres				1.609	**1.852**

*International

Velocity

The SI unit for velocity or speed is **metres per second** (m/s).

The metric unit in common use is kilometres per hour (km/h). It is not an SI unit – the hour is not SI – but it is accepted for use with the SI.

In road transport in the UK and the US, the unit is miles per hour (mph).

In aviation and marine transport, the nautical mile per hour ("knot") is widely used.

Velocity	**km/h**	**mph**	**knots**	**ft/s**
1 m/s	**3.6**	2.237	1.9425	3.281

Quick calcs: 1 m/s *is* 2 mph*;* *Add* 10% *for more accuracy:* 2.2 mph.

Personal	**A stroll**	**A fast walk**	**A jog**	**A sprint**
	1 m/s	1.5 m/s	4 m/s	10 m/s

Acceleration / Deceleration

Acceleration, or deceleration, is the rate of change of velocity; its SI unit is metres per second, per second or
metres per second squared (in symbols, m/s^2).

In the English / American system, in general, acceleration is expressed in feet per second, per second (ft/s^2).
However, in regard to vehicles, acceleration is frequently stated in the format:
0 to 60 mph in 10 seconds
That is an average acceleration of 6 mph per second.

In SI units, the latter converts to 2.7 m/s per second (2.7 m/s^2).
Humans can easily match or exceed this acceleration in, for example, starting a walk.

Earth's gravitational acceleration (standard value at mean sea level) is:
9.80665 m/s^2 (32.174 ft/s^2).
Mars: 3.71 m/s^2. *Moon:* 1.62 m/s^2.

SI Prefixes

A notable feature of the SI is the use of standard prefixes with SI units to indicate multiples and sub-multiples of the basic unit, thus avoiding a plethora of names and sizes for different quantities.

The prefixes in the general scheme vary by a factor of one thousand as shown in the table:

SI Prefixes

factor	prefix	symbol	example	meaning
10^{12}	tera	T	Ts	terasecond
10^{9}	giga	G	Gs	gigasecond
10^{6}	mega	M	Ms	megasecond
10^{3}	kilo	k	ks	kilosecond
			s	second
10^{-3}	milli	m	ms	millisecond
10^{-6}	micro	µ	µs	microsecond
10^{-9}	nano	n	ns	nanosecond
10^{-12}	pico	p	ps	picosecond

The factor 10^3 means 10 x 10 x 10 or 1000.
The factor 10^{-3} means 1/10 x 1/10 x 1/10 or 1/1000.

Multiples of 10, *deca*, and 100, *hecto*, and sub-multiples of one-tenth, *deci*, and one-hundreth, *centi* are allowed in the SI (relics of the original decimal system).

This, unfortunately, takes away from the basic simplicity of the general system and makes possible quantities such as a *hectometre* (hm) and a *decametre* (dam), and a *decimetre* (dm) as well as a *centimetre* (cm).

Better stick with the main system – preferably use metres and millimetres.

SI prefixes have also been utilised more generally, e.g. megabytes, gigabytes and terabytes of memory storage capacity in computers and smart phones.

There is no reason why further use can not be made as in a megadollar, gigadollar and teradollar.

Units, Numbers, Symbols and Prefixes: Some SI Rules

SI units are written lower-case except where normal conventions apply, such as at the start of a sentence; thus,

"six metres", not "six Metres".

The rule for SI symbols is that they are written lower-case except where the unit is named after some person:

"s" for second but "A" for ampere.

A space is used between the numerical value and the symbol; thus,

"6 m", not "6m".

The symbol remains unaltered in the plural; thus ten kilograms is written:

"10 kg", not "10 kgs"

Numbers may be written in groups of three digits to facilitate reading (1 000 000); the "decimal marker" may be the dot "(British practice)" or the comma "(French practice)" as in 9.81 or 9,81.

The EU, the UK and the US

In 1971 the Council of the EEC, by way of a directive, provided for the exclusive use within the Community of units based on SI. All products imported to the EU must comply.

The UK, as a member of the European Union, is committed to introducing "metric" units in a gradual process. Progress has been made but there remains work to be completed as distances are still indicated in miles and speed limits in miles per hour.

Since 1893 the US has had the metre/meter and the kilogram as its fundamental standards for length and mass. All units in current use are defined in terms of these standards.

In 1975 a Metric Conversion Act was introduced; in 1988 it was strengthened, requiring federal agencies to use the SI in their activities (most prominent of which have been NASA and the Department of Defence).

From 1990 the Nutrition Labeling and Education Act required food composition to be displayed in grams on food packaging.

More information:

SI units Wikipedia.

Speaking SI

In the SI the *kilogram* is the unit of mass; weight is a gravitational force and the *newton* is its unit.

There is no problem with the long-established general usage of the words formed from weigh: *weigh, weight, weightlifter, overweight, underweight, heavyweight, lightweight, weigh-in.*

The difficulty as far as the SI is concerned is the use of the unit kilogram with the word weight.

What to do? As far as the units that are in current everyday use at a personal level:

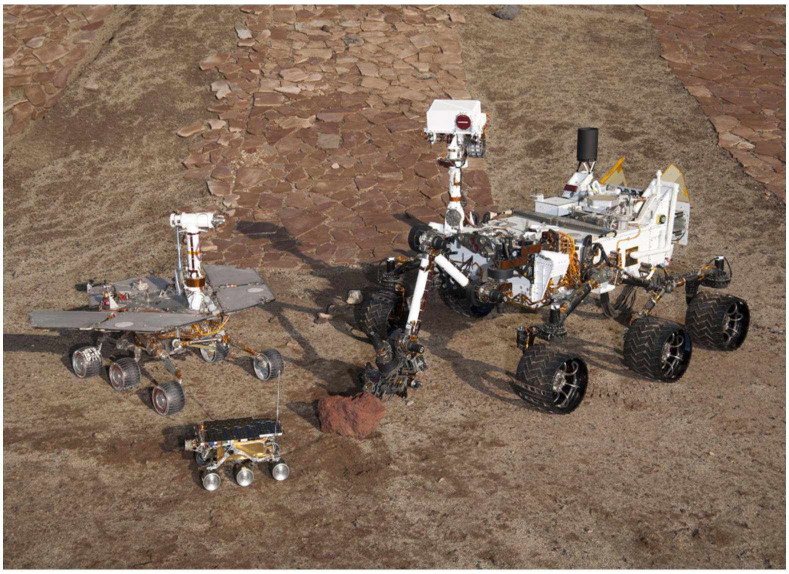
State your weight in pounds. **State your body mass in kilograms.**

If you are comfortable with SI units, better use a term like **Earth-weight** when stating the units in newtons.

Some possible SI dialogue:

What's your body mass?	Seventy kilograms.
Your height?	One sixty five.
Looks like you're a bit overweight.	I know. I need to drop a few kilos.
Let's check your BMI.	It's actually 25.7.
A bit on the high side.	Well, what about that water polo player?
She's massive – she's about 100 kg. But she has a lot of muscle mass.	I know what you're going to say – I need to tweak my diet and up my activity level.
Yes. That's it. Otherwise you're fine.	
What was the outcome of the weigh-in for the middle-weight category?	Both boxers scaled 75 kg.
What's the mass of that smart phone?	100 grams. It scales 10 to 20 grams less than its competitors.
One more time, what's its Earth-weight?	Well, it's 0.1 kg mass. Multiply by 10: that's one newton. And it means one joule to lift it one metre.
One joule every time I lift my phone?	About that. And about five joules in terms of food energy.
That's the phone only.	Yes. Include the mass of your arm to get a better estimate.
My arm mass?	I guess about 4 kilos. It's very much more than the phone.

An alien on Mars



Curiosity Rover and friends

The most recent Mars rover exploratory vehicle, named *Curiosity*, landed on Mars in August 2012.

It has a mass of 900 kg – nearly one tonne; it's about the mass of a small automobile such as the Honda Civic.

Its dimensions are: 3 m x 2.7 m x 2.2 m high.

The vehicle has an Earth-weight of 8830 newtons (8.8 kN). On Earth, to lift itself one metre requires an energy output of 8.8 kJ.

As Mars' gravitational acceleration is 3.71 m/s^2, its Mars-weight is 900 x 3.71 or 3339 newtons (3.3 kN). On Mars, to lift itself one metre requires an energy output of 3.3 kJ.

The rover has some interesting parallels with humans: it has an electrical power demand of 110 W or nearly 10 MJ per day. However, there much of the similarity ends.

The energy source is nuclear with plutonium-238 the fuel. It is safe: it emits helium nuclei and has been used for heart pacemakers.

Pu-238 has 144 neutrons and 94 protons in its nucleus.
Pu-239 is the nuclear material for bombs and reactors.
What a difference a neutron makes!

Thermal output (its "metabolic rate") is 2000 W, much of it used to maintain its systems at appropriate temperatures.

It operates at about 600 °C and powers a thermoelectric generator – a very simple and extremely reliable electricity generator with no moving parts but a very low efficiency (~ 6 %).

The power unit initially operates at about 125 W falling to 100 W after 14 years. The half-life of the nuclear source is 88 years.

Its output 88 years from now will be half its current level.

A notable feature of this alien is its seventeen "eyes". And it can fire a laser, vaporise rock and analyse it from seven metres.

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