Ergometry

1. What is ergometry?
2. Work and Power
3. Energy Units & Conversions

UNM

Ergometry

Ergometry *is a science* that measures work. A device that can be used to measure work is called an **ergometer**.

$$W = F \times D$$

where **W** = Work, **F** = Force, **D** = Distance

The **Force** must be applied against gravity, over a **Distance**

During bench stepping, body mass = *Force*, and the step height x step rate x time = *Distance*. For example;

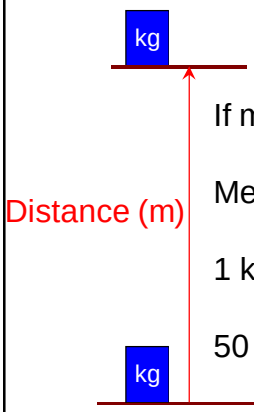
W = 70 kg x 0.25 m/step x 30 steps/min x 30 min

= 70 kg x 225 m

= **15,750 kgm**

UNM

Work and Power During Exercise

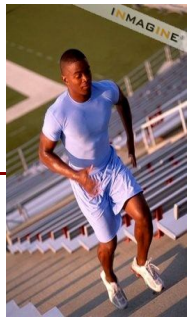


If m = 10, and kg = 5

Mechanical WORK = 10 x 5 = 50 kgm

1 kgm = 0.0098 KJoules

50 kgm x 0.0098 = 0.49 Kjoules



1 Kcal = 4.168 Kjoules

UNM

Monark™ Plate Loaded Cycle Ergometer

Weight carriage

Friction belt

Fly wheel
(6 m/crank rev'n)

UNM

Monark™ Cycle Ergometer

Friction belt

Applied force scale

Load pendulum

UNM

UNM

UNM

Cycle Ergometry

W = **F** x **D**

where **W** = Work, **F** = Force, **D** = Distance

The **Force** = Applied load (kg)

The Distance = Cadence (rev/min) x constant (**6 m**)

For example; when cycling on an ergometer at 75 rev/min, with a load of 2.75 kg for 35 min;

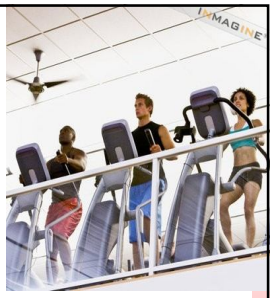
W = 2.75 kg x 75 rev/min x 6 m/rev x 35 min

= 2.75 kg x 15,750 m

= **43,312.5 kgm**

UNM

Bench Stepping



W = **F** x **D**

where **W** = Work, **F** = Force, **D** = Distance

The **Force** = Body Weight (kg)

The Distance = Step Rate (steps/min) x Step Height (m)

For example; when stepping at 30 steps/min, with a load of 78.6 kg, up and down a step height of 0.2 m for 35 min;

W = 78.69 kg x 30 steps/min x 0.2 m/step x 35 min

= 2.75 kg x 15,750 m

= **16,525 kgm**

UNM

Power is work expressed relative to time. For example (cycling, then stepping);

P = 43,312.5 kgm / 35 min

= **1,238 kgm/min**

P = 16,525 kgm / 35 min

= **472 kgm/min**

You may not recognize the units of **work** and **power** used here; kgm and kgm/min, respectively.

As physical *units of work and power can be converted to other expressions of energy*, based on the first law of bioenergetics, you need to understand ***how to convert the kgm unit to other units***.

UNM

WORK	KJ	Kcal	ft./lb	kgm
KJ	1.0	0.2388	737	1786.9
Kcal	4.1868	1.0	3086	426.8
ft./lb	0.000077	0.000324	1.0	0.1383
kgm	0.0098	0.002345	7.23	1.0

The table conversion factors represent how 1 unit listed down equals the number of units listed across; eg: 1 Kcal = 4.1868 kJ

UNM

POWER	Kgm/min	Watts	Kcal/min	KJ/min
Kgm/min	1.0	0.16345	0.00234	0.0098
Watts	6.118	1.0	0.014665	0.06
Kcal/min	426.78	69.697	1.0	4.186
KJ/min	101.97	16.667	0.2389	1.0

The table conversion factors represent how 1 unit listed down equals the number of units listed across; eg: 1 Watt = 6.118 kgm/min

1,443.75 kgm/min = 236 Watts

UNM

Ergometry can be used to better understand ***energy expenditure***, and the ***energy cost*** of performing specific exercise on ergometers.

Performing cycle ergometry at ***1,250 kgm/min for 45 min***;

1,250 kgm/min = 204.315 Watts = 3.0 Kcal/min = 12.5 KJ/min

when using KJ/min,

12.5 KJ/min x 45 min = 562.5 Kjoules

If you think this is an unusually low energy value, you are right!!

The 562.5 KJ refers to the **mechanical energy** not biological energy

562.5 KJ = ……. Kcals *(3 Kcal/min x 45 min)*

UNM

The **efficiency** of the body during exercise refers to the ratio between the change in the mechanical energy produced during exercise, to the energy used to cause the exercise (biological energy expenditure).

We can use an estimate of efficiency to adjust the mechanical energy from ergometry to biological energy expenditure

If body mechanical efficiency = 25%;

562.5 KJ = 0.25 * Biological Energy Expenditure

562.5 / 0.25 = 2,250 KJ = ……. Kcals/min

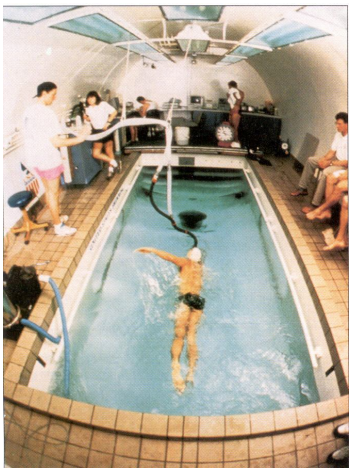
The concept of efficiency will be defined again, and discussed in more detail, in the section on calorimetry.

UNM

What Are Other Examples Of Ergometers?

Is a treadmill an ergometer ?

Does swimming involve principles of ergometry?



UNM

QUESTIONS

1. Is the 562.5 Kjoules in the prior example the value for biological energy expenditure, or mechanical energy production?

2. Is the body 100% efficient in converting biological energy to mechanical energy?

3. What should be larger, the biological or mechanical energy? Why?

4. What do we need to know to convert mechanical energy to biological energy expenditure?

UNM