Living Web Farms

Low-Tech Applied Human Power

What this workshop is about

- Making the decision to use muscles instead of motors
- Choosing what devices and appliances are appropriate for human power
- Understanding the limitations of the human body
- Learning the difference between pedal, treadle, and pump
- Understanding efficiency, drive systems, and ratio relationships
- Things to look for in repurposing and recycling items and equipment

Evolution of Human Power

- Potter's wheel, spring pole lathe, grain winnower date to BC times
- Development of flywheel preceded belt drive of 13th century and treadle of 15th century
- The spinning wheel uses all three elements to keep hands free for work
- Modern devices include treadle sewing machine, push mower, meat grinder, post drill, grinding wheel, clothes wringer, bicycle, grain grinder, hand pump and more

Energy and Power

- Work is force x distance. Measured in newton-meters, it is the transfer of energy
- One Joule is the force of one newton displaced over one meter
- Power is the rate at which work is accomplished. Power = Work/Time
- Power is measured in Watts or Joules per Second
- One Watt equals One Joule per second
- 746 Watts equals One Horsepower
- One Calorie equals 4,186 joules. (Even though Calorie is thermal energy and joules is mechanical energy there is common ground for comparison)
- Active adults consume 2,200 Calories per day or the equivalent of 106 watts
- Most of that energy is consumed in maintaining basic human functions, and any additional exertion can increase energy use by 30 percent more

- The human body is only about 25 percent efficient in its ability to convert chemical energy into work

Optimizing Human Power Potential

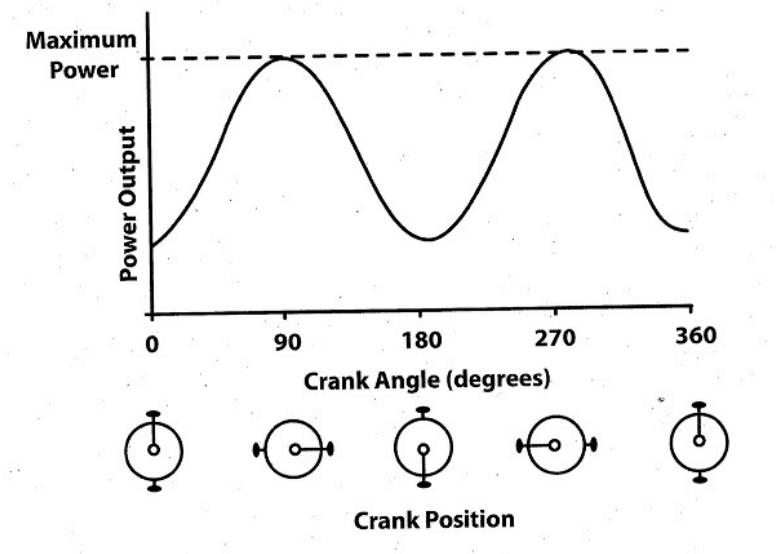
- Muscles in motion encourage the intake of oxygen and aerobic respiration which is the source of long-term energy; maintain a brisk rate
- Pay attention to your pace. A rate of 50 to 70 rpm is the optimal for pedal powered drives
- Leg power is best for tools requiring higher power inputs
- Determine the ideal position and distance between pedals/treadles and feet

Drive Systems

- The goal is to optimize efficiency and minimize losses through slippage and friction
- Direct drive is efficient but inflexible to conditions
- Chain drive is nearly as efficient and allows for ratio adjustments and changes. Efficiency increases with clean chain, tight fit to sprocket, and perfect alignment. Sprocket-chain compatibility means matching tooth size with chain width (3/32" or 1/8") and pitch (1/2")
- Belt drives are inexpensive and uncomplicated. V-belts and flat belts are most common, and a wheel with the tire removed can serve as a large drive pulley using a flat belt. A V-belt is less prone to slippage when the proper pulleys are used
- Friction drives are extremely simple and provide a quiet, convenient reduction for high-speed devices. Drawbacks include low efficiency and axle shaft wear. Best used with low-power devices

Flywheels

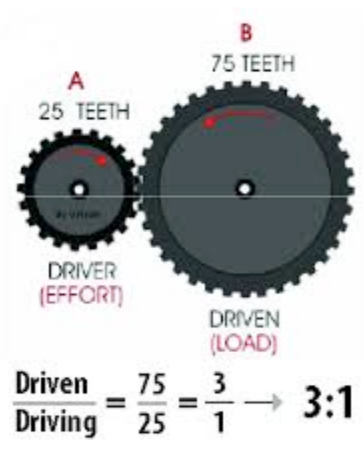
- Flywheels store kinetic (motion) energy and return it to the system when needed. The heavier and faster store more energy.
- Flywheels tend to even out irregular torque input produced by crank position (see illustration below)
- Flywheels take additional energy to get up to speed but can be maintained with reduced effort thereafter



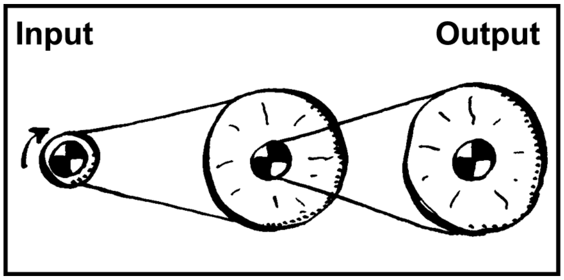
Crank position as it affects power output

Reduction Ratios and Compound Drives

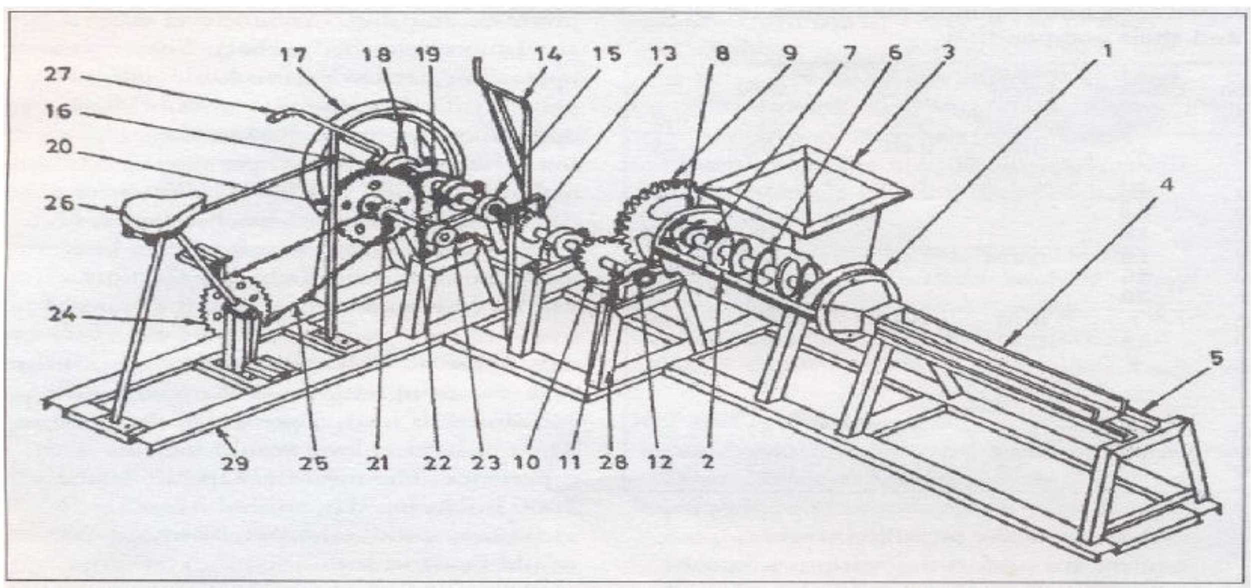
- Gear sets or combinations are used to determine the speed, direction, and force of mechanical action. This applies to chain and pulley drives as well
- The Ratio is the difference in size between two interacting gears (or sprockets, chainrings, or pulleys). To determine ratio, divide the size of the driven gear by the size of the driver gear. Example: 12-inch driven gear mated to 3-inch driver gear yields a 3:1 ratio; the driver will rotate three times for every one rotation of the driven gear
- Power vs. speed: A 3:1 ratio reduces the effort needed to accomplish the task but it happens at a slower rate. A 1:3 ratio speeds up the rate but requires more input effort to accomplish



- Compound drives are used to increase gear ratios when there are limitations on the size of available sprockets. Bicycle sprockets are usually limited to 10 or 11 teeth (about 1.6 inches)



Compound pulleys

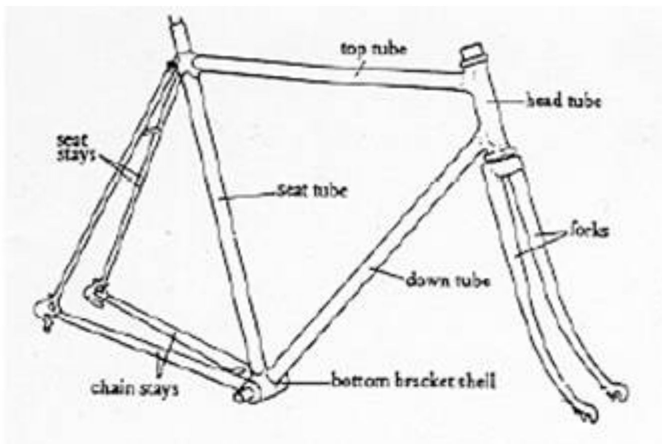


Appropriate technology brick-making device employing flywheel and compound gearing

Frames and Stays

- It is easier and cheaper to repurpose existing bicycle frames or stationary bikes than to start from scratch. Some bike trainers may also have existing or modifiable flywheels
- Fit the frame to the intended purpose. A repurposed sewing machine treadle may work for low-power appliances but you'll need a sturdy bike frame for pumps and high-speed needs
- Sturdy mounting and stability are essential for tasks requiring more effort. Extending the legs or mounting the unit on a platform may be necessary
- Plan ahead for ergodynamics. Make sure the seat height and handlebar position are practical and comfortable for extended use. Seats and handlebars are easy to replace, but basic dimensions not so much
- Be prepared to cut and modify existing bicycle frames, and substitute non-cycle components such as steel pipe and angle iron if needed. Welding skills are well worth developing, but you

can still accomplish a lot with U-bolts, straps, steel plate, and clamps. Don't be afraid to be selective when looking for used bikes and frame sizes and styles. There is a whole universe of used and discarded bicycles out there and they are relatively inexpensive or even free for the asking



Basic bicycle anatomy

Weights and Power Potential of Animals

Animal	Weight (Lbs.)	Horsepower
Oxen	1,100 to 1,980	.75
Horse	880 to 1,540	1.00
Cow	880 to 1,320	.45
Mule	770 to 1,000	.70
Donkey	440 to 660	.35
Human	130 to 200	.10

THPH

Human Power Output for Various Activities

Activity	Duration	Potential Output (Watts)
Respiration	Unlimited	.1 to 1
Hand-crank (single-arm)	1 minute	110 to 140
Hand-crank	30 minutes	40 to 45
Hand-crank	60 minutes	10 to 30
Pedal	1 minute	400 to 500
Pedal	10 minutes	300 to 400
Pedal	60 minutes	225 to 300
Pedal	Unlimited	75
From The Human-Powered Home		

Power Consumption of Typical Household Appliances

Appliance	Power Used (Watts)
Alarm clock	2 to 5
Electric toothbrush	2 to 10
Laptop computer	10 to 20
Printer	50 to 75
Fan	48 to 120
Stereo	30 to 100
Sewing machine	75 to 100
Color TV (CRT)	100 to 300

Color TV (plasma)	300 to 400
Blender	300 to 400
Washing machine	500 to 900
Vacuum cleaner	1,000 to 2,000
Table saw	1,200 to 2,000

Resources

The Human-Powered Home by Tamara Dean; New Society Publishers; ISBN: 978-0-86571-601-8

Probably the most complete reference book available for the down-to-earth application of human power for operating tools, kitchen appliances, and many other everyday devices. Includes photos, illustrations, and clear explanations of the mechanical requirements needed to convert or build your own equipment

Low-Tech Magazine http://www.lowtechmagazine.com/build-your-own-pedal-powered-machines.html

A good resource variety for building your own pedal-powered machines, with links to free plans and other resources

Instructables http://www.instructables.com/id/Universal-Nut-Sheller/

The Full Belly Project is a non-profit whose objective is to aid in food production for developing countries by providing simple and easily accessible technology. The link above is for a Universal Nut Sheller. The link here https://www.youtube.com/watch?v=bCIzeMzNmyM describes a foot-powered rocker pump

Table of Radius Values for Bicycle Sprockets

http://www.machinehead-software.co.uk/bike/chain_length/sprocket_radius_table.html

Mark Dempsey's Pedal Lathe

https://www.youtube.com/watch?v=OFsoE5hlvG4