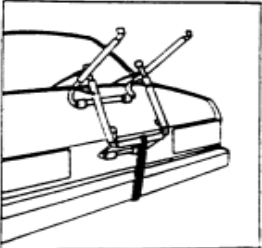
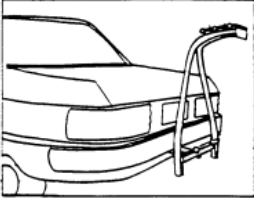
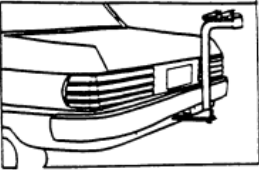
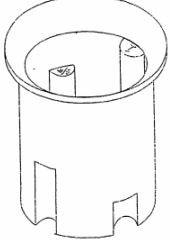
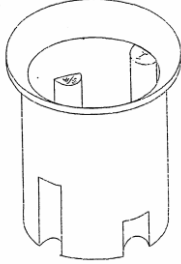
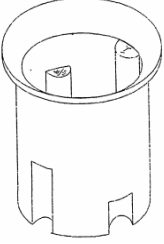
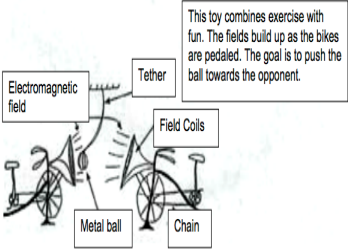
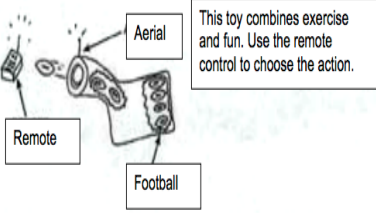
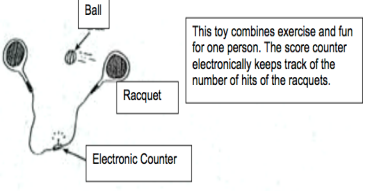



Supplementary Material A

The Problems and Examples Used in Each Independent Study

ID	Year	Author	Task	Examples
Studies Presenting Non-Negative Examples				
1	1992	Purcell & Gero	Design a car-mounted bicycle rack <ul style="list-style-type: none"> • Easy mounting of the bicycle • Easy mounting of the rack • Cannot harm bike or car Must be versatile for all bikes and cars	Bicycle rack (boot) 
2	1992	Purcell & Gero	Design a car-mounted bicycle rack <ul style="list-style-type: none"> • Easy mounting of the bicycle • Easy mounting of the rack • Cannot harm bike or car Must be versatile for all bikes and cars	Bicycle rack (A frame) 
3	1992	Purcell & Gero	Design a car-mounted bicycle rack <ul style="list-style-type: none"> • Easy mounting of the bicycle • Easy mounting of the rack • Cannot harm bike or car Must be versatile for all bikes and cars	Bicycle rack (single) 
4	1992	Purcell & Gero	Design a car-mounted bicycle rack <ul style="list-style-type: none"> • Easy mounting of the bicycle • Easy mounting of the rack • Cannot harm bike or car Must be versatile for all bikes and cars	Bicycle rack (A frame) (word)
5	1992	Purcell & Gero	Design a car-mounted bicycle rack <ul style="list-style-type: none"> • Easy mounting of the bicycle • Easy mounting of the rack • Cannot harm bike or car Must be versatile for all bikes and cars	Bicycle rack (single) (word)
6	1993	Purcell, Williams, Gero, & Colbron	Design a measuring cup for the blind <ul style="list-style-type: none"> • Easy operation by the blind • Use for powders and liquids • Prevent waste of food products • Graduate from 1/4 to 2 cups • No splatter during operation • Easy to clean • Inexpensive 	4 Large (finger sized) graduation marks raised Arabic numeral labels 
7	1993	Purcell, Williams, Gero, & Colbron	Design a measuring cup for the blind	4 Large (finger sized) graduation marks raised Arabic numeral labels

				
8	1993	Purcell, Williams, Gero, & Colbron	Design a measuring cup for the blind	<p>4 Large (finger sized) graduation marks raised Arabic numeral labels</p> 
9	1993	Smith, Ward, & Schumacher	Invent new toys you had never seen before	<p>Example 1</p>  <p>Example 2</p>  <p>Example 3</p> <p>Example Toys</p> 
10	2002	Dahl & Moreau	<p>Design a product that will meet the needs/solve the problems of the commuting diner</p> <ul style="list-style-type: none"> • Inability in preparing food items • Spillage of food and beverages • Difficulty in food consumption • Problem with temporary food storage <p>The new product should be</p>	<p>Drive in window food tray</p>

			practical and effective, safe to use, reusable, portable, and easy to assemble and use.	
11	2002	Dahl & Moreau	<p>Design a product that will meet the needs/solve the problems of the commuting diner</p> <ul style="list-style-type: none"> • Inability in preparing food items • Spillage of food and beverages • Difficulty in food consumption • Problem with temporary food storage <p>The new product should be practical and effective, safe to use, reusable, portable, and easy to assemble and use.</p>	Drive in window food tray
12	2002	Dahl & Moreau	<p>Design a product that will meet the needs/solve the problems of the commuting diner</p> <ul style="list-style-type: none"> • Inability in preparing food items • Spillage of food and beverages • Difficulty in food consumption • Problem with temporary food storage <p>The new product should be practical and effective, safe to use, reusable, portable, and easy to assemble and use.</p>	Drive in window food tray
13	2002	Dahl & Moreau	<p>Design a product that will meet the needs/solve the problems of the commuting diner</p> <ul style="list-style-type: none"> • Inability in preparing food items • Spillage of food and beverages • Difficulty in food consumption • Problem with temporary food storage <p>The new product should be practical and effective, safe to use, reusable, portable, and easy to assemble and use.</p>	Drive in window food tray, cup holder, lunch box, airplane foldout table (multiple)
14	2006	Pettula & Sipilä	<p>Design an automatic watering device. The device should provide a plant with about a decilitre of water per week - no more or less. The device should be able to water the plant for a minimum of one month</p>	<p>Example 1</p> <p>An ice-cube that is inside a thermostate-bag is inserted into the flower-pot. The ice-cube can be defreezed/freezed by changing the temperature of the bag to release water to the plants</p>  <p>Example 2</p> <p>A water-container is integrated to the flower-pot. The water slowly vaporizes and saturates the mould through breathing-pipes.</p>



Example 3

An electronic pump stand on the side of the plants. Watering is regulated by a timer.



Example 4

Four water-bags hang from a stand. A bag is punctured when desired to release water to the plant.



15 2008 Tseng, Moss, Cagan, & Kotovsky Design a device to measure the passage of hours, minutes, and seconds

Example 1

Grandfather clock. Grandfather clock. A grandfather clock uses the constant period of a swinging pendulum to provide a continuous and stable reference frequency. This pendulum in turn drives the escapement, which is generally a gear and a pair of stops, which are actuated by the pendulum, that allow one tooth of the escapement's gear to 'escape' after each full swing of the pendulum. The engagement of the two stops results in the characteristic 'tick' and 'tock' sounds of a clock. The escapement's gear is connected to a series of gears that control the relative speed of rotation between the escapement and the hands of the clock, the bells, and other elements of the clock. The energy to drive the hands is provided by a set of drop ping weights that drop a small amount per cycle. These weights also provide just enough energy to the pendulum to overcome friction via the escapement.

Example 2

Windup clock. A windup clock uses the constant period of a spring powered rotating mass or flywheel, which works much like a pendulum in providing a continuous and stable reference frequency. This flywheel drives an escapement much like as used in a grandfather clock, which in turn drives the hands and other functions of the clock. The flywheel is generally small and turns at a much higher frequency than a pendulum, which results in the ability to drive a second hand. The power to drive the flywheel and the hands is provided by a spring, which is tensioned by winding.

Example 3

Quartz wristwatch. A quartz wristwatch uses an electronic quartz crystal oscillator to provide a constant period. Most battery-powered crystal clocks use a 32,768 kHz oscillator. Using the piezoelectric effect, an excited crystal generates voltage pulses, which are then divided down using a frequency divider or counter and used to drive a tiny electric motor, which in turn drives the hands and other functions of the wristwatch.

16 2008 Tseng, Moss, Cagan, Design a device to measure the

Example 1

		& Kotovsky	passage of hours, minutes, and seconds	<p>Heart rate monitor. A heart rate monitor is a device that allows a user to measure his or her heart rate in real time. It usually consists of two elements: a chest strap transmitter and a wrist receiver (which usually doubles as a watch). Strapless heart rate monitors are available as well, but lack some of the functionality of the original design. Advanced models additionally measure heart rate variability to assess a user's fitness. The chest strap has electrodes in contact with the skin to monitor the electrical voltages in the heart. When a heartbeat is detected a radio signal is sent out which the receiver uses to determine the current heart rate.</p> <p>Example 2 Cassette tape deck. A tape recorder, tape deck, reel-to-reel tape deck, cassette deck or tape machine is an audio storage device that records and plays back sound using magnetic tape, either wound on a reel or in a cassette, for storage. It records a fluctuating signal by moving the tape across a tape head that polarizes the magnetic domains in the tape in proportion to the audio signal. Professional recorders usually use a simple three-motor scheme. One motor with a constant rotation speed provides traction for the leading wheel that is usually combined with a capstan and flywheel to ensure that the tape speed does not fluctuate. The other two motors apply constant torque to maintain the tape's tension or wind the tape quickly. Cheaper models use a single motor for all required functions. There are also variants with two motors, in which one motor is used for rewinding only.</p> <p>Example 3 Water meter. A water meter is a device used to measure water usage. Water meters are normally used at every residence and commercial building in a public water system. Water meters can also be used at the water source, well, or throughout a water system to determine flow through that portion of the system. Water meters typically measure and display total usage in US gallons, cubic feet, or cubic meters on a mechanical or electronic register. Water meters typically fall into two categories. A displacement type water meter relies on the water to physically displace the moving measuring element in direct relation to the amount of water that passes through the meter. The piston or disk moves a magnet that drives the register. A velocity type water meter measures the velocity of flow through a meter of a known internal capacity. The speed of the flow can then be converted into volume of flow for usage.</p>
17	2008	Tseng, Moss, Cagan, & Kotovsky	Design a device to measure the passage of hours, minutes, and seconds	<p>Example 1 Heart rate monitor. A heart rate monitor is a device that allows a user to measure his or her heart rate in real time. It usually consists of two elements: a chest strap transmitter and a wrist receiver (which usually doubles as a watch). Strapless heart rate monitors are available as well, but lack some of the functionality of the original design. Advanced models additionally measure heart rate variability to assess a user's fitness. The chest strap has electrodes in contact with the skin to monitor the electrical voltages in the heart. When a heartbeat is detected a radio signal is sent out which the receiver uses to determine the current heart rate.</p> <p>Example 2 Cassette tape deck. A tape recorder, tape deck, reel-to-reel tape deck, cassette deck or tape machine is an audio storage device that records and plays back sound using magnetic tape, either wound on a reel or in a cassette, for storage. It records a fluctuating signal by moving the tape across a tape head that polarizes the magnetic domains in the tape in proportion to the audio signal. Professional recorders usually use a simple three-motor scheme. One motor with a constant rotation speed provides traction for the leading wheel that is usually combined with a capstan and flywheel to ensure that the tape speed does not fluctuate. The other two motors apply constant torque to maintain the tape's tension or wind the tape quickly. Cheaper models use a single motor for all required functions. There are also variants with two motors, in which one motor is used for rewinding only.</p> <p>Example 3 Water meter. A water meter is a device used to measure water usage. Water meters are normally used at every residence and commercial building in a public water system. Water meters can also be used at the water source, well, or throughout a water system to determine flow through that portion of the system. Water meters typically measure and display total usage in US gallons, cubic feet, or cubic meters on a mechanical or electronic register. Water meters typically fall into two categories. A displacement type water meter relies on the water to physically displace the moving measuring element in direct relation to the amount of water that passes through the meter. The piston or disk moves a magnet that drives the register. A velocity type water meter measures the velocity of flow through a meter of a known internal capacity. The speed of the flow can then be converted into</p>

- 18 2010 Wilson, Rosen, Nelson, & Yen
- Design a device to immobilize a joint or limb in case of an extreme injury in backpacking /hiking
- as light and small as possible when stored in the guides' pack
 - rigid enough and large enough to immobilize the leg of an average-sized male

Echinoderms (ie. Sea cucumbers) possess the ability to control the tensile properties (stiffness) of their skin by regulating the stress transfer between collagen fibril bundles. Interactions between these fibril bundles are regulated by special cells controlled by the sea cucumber's neural system. In its low stiffness state, the individual collagen fibril bundles are allowed to slide past to one another. When signaled by neural system, the special cells release a binding agent, called stiparin, which causes the individual fiber bundles to become linked. This causes the high-stiffness state of the skin.

The skin tissue can be modeled as a flexible composite of discontinuous fibrils within a viscous liquid medium. The force transferred through the solution to the fibrils depends on the size and orientation of the fibrils. Once activated, these fibrils become linked into a network of larger, continuous fibers (figure 1). This increase size leads to an increased contribution on their part to the stiffness of the skin.

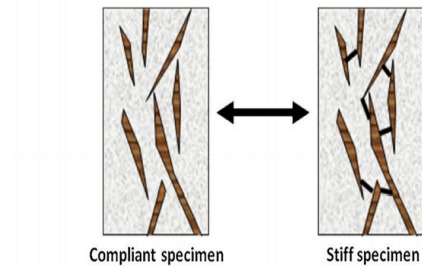


Figure 1. Model of the Echinoderm skin

- 19 2010 Wilson, Rosen, Nelson, & Yen
- Design a device to immobilize a joint or limb in case of an extreme injury in backpacking /hiking
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Electrorheological (ER) fluids are fluids that experience increased yield stress in the presence of electric field. ER fluids consist of extremely small non-conducting particles suspended in an electrically insulating carrier fluid medium. In the absence of an electric field, ER fluids behave as typical fluids (Figure 1a). When an electric field is applied, these particles bind and the fluid immediately 'solidifies' with a yield point determined by the electric field strength (Figure 1b).

One application of this technology is in the US Army's planned Future Force Warrior project. In this project, the Army plans to create bullet-resistant armor using the ER fluid, whereby the stiffness of the armor can be actively-controlled.

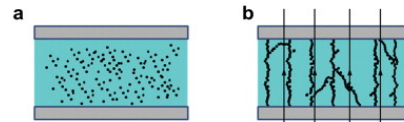
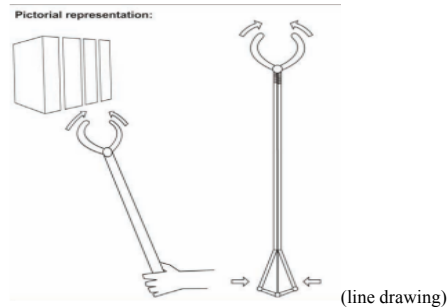
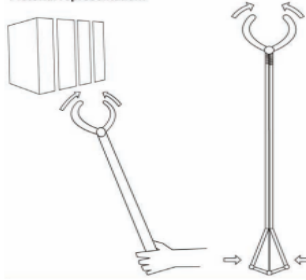
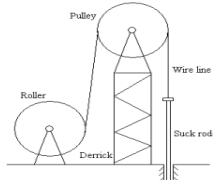
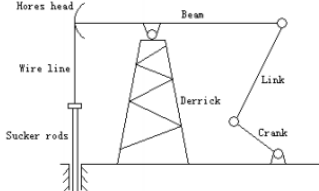


Figure 1. (a) ER fluid with zero electric field applied (b) ER fluid solidifies when electric field is applied

- 20 2011 Cardoso & Badke-Schaub
- Design a device to help people to pickup a book from a shelf that is out of reach



21	2011	Cardoso & Badke-Schaub	Design a device to help people to pickup a book from a shelf that is out of reach	<p>Pictorial representation:</p>  <p>(photo)</p>
22	2011	Chan, et al	<p>Design a device to collect energy from human motion for use in developing and impoverished rural communities.</p> <ul style="list-style-type: none"> • Used by low power draw electrical devices • Provide energy to be stored in a rechargeable battery with approximately 80% efficiency • low cost • easy to maintain 	<p>Freeway power generator: A series of magnetized cylindrical rollers are rotatably mounted in spaced transverse channels under a freeway off ramp. Each roller is made of non-magnetic material and has plurality of cavities around its rim in which arcuate bar magnets are mounted. The bar magnets are arranged with like poles adjacent each other to produce magnetic spokes which penetrate the off ramp and extend into the space traversed by vehicles travelling along the off ramp. Motion of the vehicles induces rotation of the magnetic rollers by magnetic interaction with the magnetic spokes. Electrical generators are coupled to the rollers to change their rotary motion into electrical energy.</p>
23	2011	Chan, et al	<p>Design a device to collect energy from human motion for use in developing and impoverished rural communities.</p> <ul style="list-style-type: none"> • Used by low power draw electrical devices • Provide energy to be stored in a rechargeable battery with approximately 80% efficiency • low cost • easy to maintain 	<p>Accelerometer: An accelerometer comprises an electric coil pivotally mounted in a magnetic field about an axis extending perpendicular to the field for oscillatory movement substantially perpendicular to the field, in the manner of a D'Arsonval movement. Switching means in the form of a radiation source and detector responds to movement of the coil assembly when on either side of a switching position to apply a constant current to the coil to move it in the direction of the switching position, thereby setting up an oscillation of the coil. Linear acceleration is measured by having an inertial mass, such as provided by mounting the coil away from its center of mass, displaced from the pivotal axis. An acceleration force acting on the mass of the oscillating coil alters the proportion of time spent at each side of the switching position to give an average current flow in the coil related to the magnitude of acceleration. More than one coil may be provided to measure acceleration along a number of axes.</p>
24	2011	Chan, et al	<p>Design a device to collect energy from human motion for use in developing and impoverished rural communities.</p> <ul style="list-style-type: none"> • Used by low power draw electrical devices • Provide energy to be stored in a rechargeable battery with approximately 80% efficiency • low cost • easy to maintain 	<p>Virtual-wheeled vehicle: A virtual wheel provides a leg pair as a conveyance mechanism for a land vehicle. The virtual wheel propels the vehicle across a surface using a repetitive motion of the legs that contact the ground as would a wheel, due to their geometry. Vehicle embodiments include at least two-, three-, four- and six-wheeled vehicles, both transverse and in-line. Additionally, the invention provides a bipedal walking robot. One embodiment provides a robotic mule--a payload-carrying vehicle. The invention combines the flexible mobility of bipedal vehicles with the stability and functionality of very large-wheeled vehicles. Additionally, a bimodal conveyance mechanism readily converts between walking and rolling modes.</p>
25	2011	Chan, et al	<p>Design a device to collect energy from human motion for use in developing and impoverished rural communities.</p> <ul style="list-style-type: none"> • Used by low power draw electrical devices • Provide energy to be stored in a rechargeable battery with approximately 80% efficiency • low cost • easy to maintain 	<p>Escapement mechanism for pendulum clocks: A pendulum clock mechanism may have an escapement coupled to a conventional pendulum bob by means of an anchor arbor which is frictionally or slip coupled to an anchor having at least a pair of pallet pins symmetrically disposed thereon for engagement to an escape wheel. The pallet pins engage the escape wheel in a conventional manner to regulate the operation of a conventional clock gear train. The anchor automatically rotates to a position of design equilibrium regardless of improper vertical installment of the clock or excessive torques applied to the escapement mechanism.</p>
26	2011	Chan, et al	<p>Design a device to collect energy from human motion for use in developing and impoverished rural communities.</p> <ul style="list-style-type: none"> • Used by low power draw electrical devices • Provide energy to be stored in a rechargeable battery with approximately 80% efficiency • low cost • easy to maintain 	<p>Freeway power generator: A series of magnetized cylindrical rollers are rotatably mounted in spaced transverse channels under a freeway off ramp. Each roller is made of non-magnetic material and has plurality of cavities around its rim in which arcuate bar magnets are mounted. The bar magnets are arranged with like poles adjacent each other to produce magnetic spokes which penetrate the off ramp and extend into the space traversed by vehicles travelling along the off ramp. Motion of the vehicles induces rotation of the magnetic rollers by magnetic interaction with the magnetic spokes. Electrical generators are coupled to the rollers to change their rotary motion into electrical energy.</p>

27	2011	Chan, et al	<p>Design a device to collect energy from human motion for use in developing and impoverished rural communities.</p> <ul style="list-style-type: none"> • Used by low power draw electrical devices • Provide energy to be stored in a rechargeable battery with approximately 80% efficiency • low cost • easy to maintain 	<p>Accelerometer: An accelerometer comprises an electric coil pivotally mounted in a magnetic field about an axis extending perpendicular to the field for oscillatory movement substantially perpendicular to the field, in the manner of a D'Arsonval movement. Switching means in the form of a radiation source and detector responds to movement of the coil assembly when on either side of a switching position to apply a constant current to the coil to move it in the direction of the switching position, thereby setting up an oscillation of the coil. Linear acceleration is measured by having an inertial mass, such as provided by mounting the coil away from its center of mass, displaced from the pivotal axis. An acceleration force acting on the mass of the oscillating coil alters the proportion of time spent at each side of the switching position to give an average current flow in the coil related to the magnitude of acceleration. More than one coil may be provided to measure acceleration along a number of axes.</p>
28	2011	Chan, et al	<p>Design a device to collect energy from human motion for use in developing and impoverished rural communities.</p> <ul style="list-style-type: none"> • Used by low power draw electrical devices • Provide energy to be stored in a rechargeable battery with approximately 80% efficiency • low cost • easy to maintain 	<p>Virtual-wheeled vehicle: A virtual wheel provides a leg pair as a conveyance mechanism for a land vehicle. The virtual wheel propels the vehicle across a surface using a repetitive motion of the legs that contact the ground as would a wheel, due to their geometry. Vehicle embodiments include at least two-, three-, four- and six-wheeled vehicles, both transverse and in-line. Additionally, the invention provides a bipedal walking robot. One embodiment provides a robotic mule--a payload-carrying vehicle. The invention combines the flexible mobility of bipedal vehicles with the stability and functionality of very large-wheeled vehicles. Additionally, a bimodal conveyance mechanism readily converts between walking and rolling modes.</p>
29	2011	Chan, et al	<p>Design a device to collect energy from human motion for use in developing and impoverished rural communities.</p> <ul style="list-style-type: none"> • Used by low power draw electrical devices • Provide energy to be stored in a rechargeable battery with approximately 80% efficiency • low cost • easy to maintain 	<p>Escapement mechanism for pendulum clocks: A pendulum clock mechanism may have an escapement coupled to a conventional pendulum bob by means of an anchor arbor which is frictionally or slip coupled to an anchor having at least a pair of pallet pins symmetrically disposed thereon for engagement to an escape wheel. The pallet pins engage the escape wheel in a conventional manner to regulate the operation of a conventional clock gear train. The anchor automatically rotates to a position of design equilibrium regardless of improper vertical installment of the clock or excessive torques applied to the escapement mechanism.</p>
30	2011	Lujun	Design a pumping unit for extracting petroleum	<p>The working principle of the example solution is as follows. The motor drives the roller to rotate forward (clockwise) or backward (counterclockwise). The roller rotating forward winds the wire line to drive sucker rods to go up. The roller rotating backward releases the wire line to make sucker rods go down. Reciprocating movement of the sucker rods drives the pump to extract petroleum</p>  <p>Figure 1. Example of roller drive pumping unit</p>
31	2011	Lujun	Design a pumping unit for extracting petroleum	<p>The working principle of the example solution is as follows. Rotating continually under the drive of the motor, the crank drives the beam to swing (crank-rocker mechanism). The swing of the beam drives the sucker rods to go up and down. Reciprocating movement of the sucker rods drives the pump to extract petroleum</p>  <p>Figure 2. Example of beam pumping unit</p>
32	2011	Lujun	Design a pumping unit for extracting petroleum	<p>You can refer to example solution shown in Fig.3 during ideation. The working principle of the example solution is as follows. The rail car can move forward and backward. When moving forward, the car can drive sucker rods to go up. When moving backward, the car can make sucker rods go down. Reciprocating movement of the sucker rods drives the pump to extract petroleum.</p>

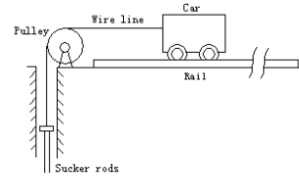
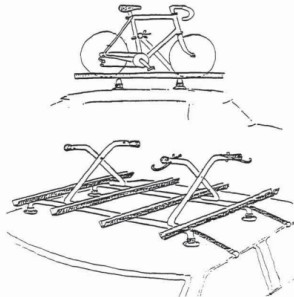
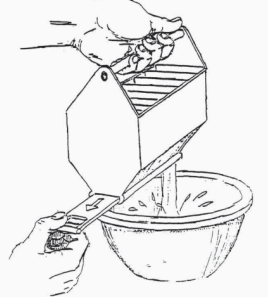


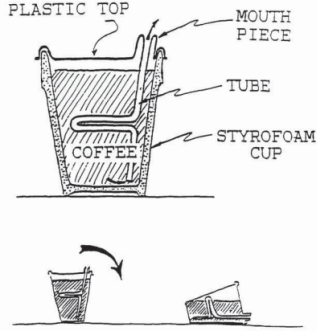
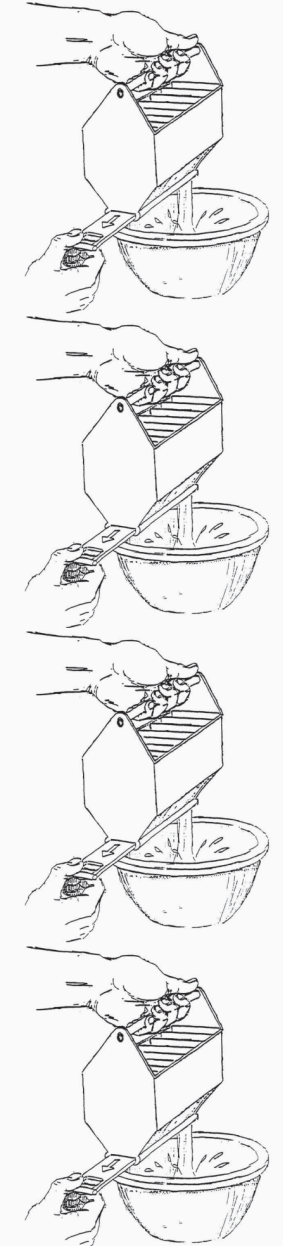
Figure 3. Example of car drive pumping unit

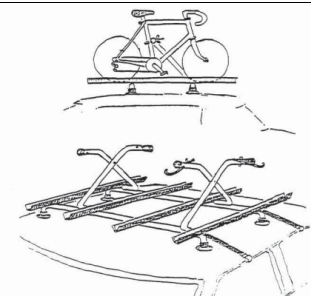
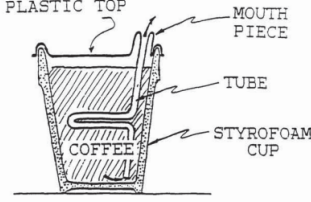
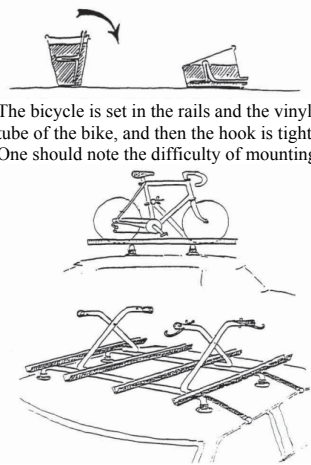
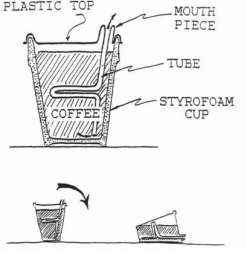
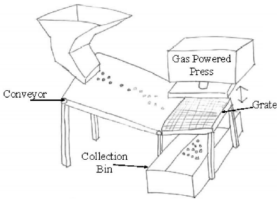
33	2012	Cardoso, Gonçalves, & Badke-Schaub	Whathuman transportation will be like in 2050	transportation system (picture)
34	2012	Cardoso, Gonçalves, & Badke-Schaub	How human transportation will be like in 2050	<p>Straddling Bus: A boom in car sales has caused traffic mayhem in many of China's major cities. One company wants to improve the situation — by putting even more people on the road. But rather than add more cars, Shenzhen Huashi Future Parking Equipment is developing a massive "straddling bus." Cheaper than a subway, the partly solar-powered behemoth will span two lanes and carry up to 1,200 people in a carriage raised 7 ft. above the roadway, thus allowing cars to pass, or be passed, underneath. Passengers on the new bus should rightly expect to feel above it all. The company is awaiting government approval for a trial project in Beijing. If that comes through this year, test runs could begin by the end of 2011.</p>
35	2012	Gonçalves, et al.	What human transportation will be like in 2050	<p>Straddling Bus: A boom in car sales has caused traffic mayhem in many of China's major cities. One company wants to improve the situation — by putting even more people on the road. But rather than add more cars, Shenzhen Huashi Future Parking Equipment is developing a massive "straddling bus." Cheaper than a subway, the partly solar-powered behemoth will span two lanes and carry up to 1,200 people in a carriage raised 7 ft. above the roadway, thus allowing cars to pass, or be passed, underneath. Passengers on the new bus should rightly expect to feel above it all. The company is awaiting government approval for a trial project in Beijing. If that comes through this year, test runs could begin by the end of 2011.</p>
36	2012	Gonçalves, et al.	What human transportation will be like in 2050	<p>An excerpt from the book The Wonderful Wizard of Oz by L. Frank Baum. In it, Dorothy, the main character, is lifted by a cyclone while inside her house.</p>
37	2013a	Fu, et al.	<p>Design a device to collect energy from human motion for use in developing and impoverished rural communities.</p> <ul style="list-style-type: none"> • Used by low power draw electrical devices • Provide energy to be stored in a rechargeable battery with approximately 80% efficiency • low cost • easy to maintain 	<p>Seat arrangement for sitting furniture: A seat arrangement for sitting furniture such as chairs has a seat member and a support arranged underneath the seat member, wherein the support has an elastic body allowing a tilting movement of the seat member about a pivot point arranged at the central seat member area. The elastic body is arranged at the center of the seat member and has an upper side and an underside. The support has a rigid top plate fixedly connected to the upper side of the elastic body and a rigid bottom plate fixedly connected to the underside of the elastic body. The top plate is correlated with the seat member and the bottom plate is correlated with an underframe of the sitting furniture. The same type of tilting support can also be arranged on a backrest of a chair.</p> <p>Power transmission device for sewing machine: A power transmission device serves to transmit rotation of a main shaft of a sewing machine to a slave shaft of the sewing machine, which slave shaft extends in a torsional relationship with the main shaft. The device includes a first timing pulley mounted on the main shaft, a second timing pulley mounted on the slave shaft and a timing belt extending between the first and second timing pulleys in a twisted form.</p> <p>Thread clamping device figuring weft threads on jacquard machines: A thread clamping device, particularly for the figuring weft threads on jacquard machines, in which figuring weft threads, e.g. those on jacquard looms, are only picked from time to time corresponding to the figured form of the woven jacquard fabric, with the figuring weft threads being held under tension and released as required, during their stationary period, by thread clamping devices which are controlled via the harness thread of the associated figuring weft cord heald.</p> <p>Toy vehicle track: A toy vehicle track with toy vehicles having an electric drive motor disposed in the chassis thereof. The track is formed of segments which are connected by plugging together. The electric drive motor in the vehicles is supplied with electricity via collectors and conductors placed in the track for uninterrupted operation over a period of time. When electrical connection with a net fails or is terminated, the vehicles can be operated over a further preset length of time. The segments are removably or fixedly connected with conductors along the entire track. The vehicles have collectors in contact with the conductors and a chargeable power source serving as an electric buffer. The power source and the collectors are simultaneously in permanent connection with the drive motor. If the power supply is cut off from the electric net, the internal power source is automatically activated, and permits further operation until discharged. The conductors on the segments are formed by metal foil or metal foil segments, by electrically conductive formed parts</p>

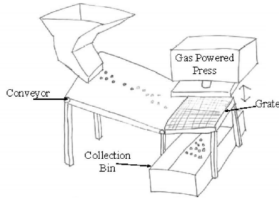
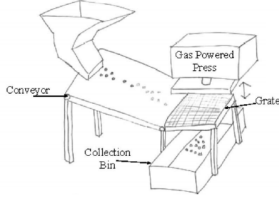
			<p>clampingly clipped to the individual segments, which are either removably clippable to the edge members or on the segments in the area of the track surfaces, or they are irremovably fixed with the segments.</p>
38	2013a Fu, et al.	<p>Design a device to collect energy from human motion for use in developing and impoverished rural communities.</p> <ul style="list-style-type: none"> • Used by low power draw electrical devices • Provide energy to be stored in a rechargeable battery with approximately 80% efficiency • low cost • easy to maintain 	<p>Safety ski binding: A heel holder includes a sole holder which is supported for pivotal movement about a horizontal axis on a support member and has a control surface. A locking lever pivotally supported on the support member has a nose engageable with the sole holder control surface. A spring housing having a release spring therein is pivotal about the sole holder pivot axis, and a slide member movably supported in the spring housing is biased by the release spring against a side of the lever opposite the nose thereof when the spring housing is in an initial position. A centering spring is cooperable with the spring housing and with the sole holder or the support member and, after pivotal movement of the spring housing away from its initial position, urges the spring housing back toward such position.</p> <p>Compensating rope sheave tie down: A compensating rope sheave tie down assembly prevents the compensating rope sheave from sudden upward movement if the elevator car suddenly jumps upward. The compensating rope sheave assembly comprises a strap, an inertia reel that permits the strap to follow slow movement of the compensating rope sheave, and a spring retaining mechanism that maintains the strap taut at all times. By restricting the upward movement of the sheave, the sheave tie down prevents further upward movement of the elevator car as well.</p> <p>Hanger tilt mechanism for hanging transportation apparatus: A hanger tilt mechanism for a hanging transportation apparatus in which a carrier traveling along a rail is equipped with a hanger having a circular arc-shaped portion so as to be tiltable. The carrier is further equipped with a driving motor and a tilt mechanism for transmitting a rotational force of the driving motor to the circular arc-shaped portion for tilting the hanger. The tilt mechanism, in a preferred embodiment, includes a chain stretched along the circular arc-shaped portion of the hanger and a sprocket which meshes with the chain and is rotated by the driving motor.</p> <p>Shelter structure: A shelter structure comprising a supporting framework which includes a pair of spaced apart base members, each base member comprising a plurality of stationary receptacles. A plurality of ribs extend between the base members and have end portions removably mounted to respective stationary receptacles of the base members to form a skeleton frame which is covered by a skin. Each base member also comprises a movable receptacle capable to removeably hold the end portion of a rib. To erect the shelter, the ribs are temporarily mounted in the stationary receptacles of the base members to form a skeleton frame, the skin is mounted to the skeleton frame and one or more selected ribs which ultimately will form the door of the shelter structure are transferred from their respective stationary receptacles to movable receptacles so as to allow the ribs to move between an opened and a closed position relatively to the other ribs of the shelter.</p> <p>Converging sphere joint assembly: A ball and socket joint includes a stud having a shank connected to a ball stud, which is received in a ball stud housing. A one piece bearing shell is provided having a generally spherically shaped hollow body with an inner surface to matingly engage the ball stud and an outer surface for contacting the stud housing. Moreover, the outer bearing shell surface includes a first spherical portion having a first radius and first center and a second spherical portion having a second radius and second center. The first and second centers are axially offset relative to each other to create a converging sphere design that permits a low profile design. The converging sphere design also permits more effective compression pre-loading on the bearing sleeve as compared to a single spherical outer surface.</p>
39	2013b Fu, et al.	<p>Design a device to collect energy from human motion for use in developing and impoverished rural communities.</p> <ul style="list-style-type: none"> • Used by low power draw electrical devices • Provide energy to be stored in a rechargeable battery with approximately 80% efficiency • low cost • easy to maintain 	<p>Fuel injection apparatus having fuel pressurizing pump: a fuel injection apparatus has a piezoelectric element for generating a high-pressurized air-fuel gas mixture. The piezoelectric element is arranged at a side of a pumping chamber, and a diaphragm is arranged between the piezoelectric element and the pumping chamber. The piezoelectric element produces a pumping function in accordance with a current signal.</p> <p>Inflating/deflating device for an inflatable air mattress: an inflating/deflating device includes a fan unit disposed inside a main housing. A release valve assembly is connected to a deflating port of the main housing for fluid communication with a first air passage of the fan unit. An inlet valve assembly is connected to an inflating port of the main housing for fluid communication with a second air passage of the fan unit. A control unit is provided to control the release and inlet valve assemblies. The control unit is operable to switch a</p>

			<p>first or a second actuating position. The control unit actuates the fan unit and the inlet valve assembly to perform an inflating mode in the first actuating position, and actuates the fan unit and the release valve assembly to perform a deflating mode in the second actuating position.</p> <p>Wireless communication device and signal receiving/transmitting method: a wireless communication device using a single spiral inductor antenna and a signal receiving/transmitting method thereof operated on multi-band are provided. The single spiral inductor antenna is designed to have a plurality of different inductance paths. Different inductance values are inducted with signal paths switched by a plurality of switches so as to meet the requirements of multi-band operation. As the circuit structure of the single spiral inductor antenna is used, the circuit area is reduced effectively.</p> <p>Paper guiding arrangement for a business machine: a paper roll supplies a paper band through an inlet opening in the housing of a business machine to a platen which transports the paper band back towards the top of the paper roll. When the diameter of the paper roll is small, the paper band is curved and tends to reenter the inlet opening which is prevented by a closure means mounted on the carrier of the paper roll and substantially closing the inlet opening when the carrier is displaced due to the reduction of the diameter of the paper roll.</p>
40	2013b	Fu, et al.	<p>Design a device to collect energy from human motion for use in developing and impoverished rural communities.</p> <ul style="list-style-type: none"> • Used by low power draw electrical devices • Provide energy to be stored in a rechargeable battery with approximately 80% efficiency • low cost • easy to maintain <p>Photovoltaic cell powered magnetic coil for operation of fluidic circuit flapper: a photofluidic eye comprising a photovoltaic cell and a magnetic coil operated flapper assembly powered thereby for alternately opening and closing fluidic back pressure orifices. No external power or switching arrangement is employed to avoid the occurrence of an electric spark when an environment containing explosive materials is present.</p> <p>Virtual-wheeled vehicle: A virtual wheel provides a leg pair as a conveyance mechanism for a land vehicle. The virtual wheel propels the vehicle across a surface using a repetitive motion of the legs that contact the ground as would a wheel, due to their geometry. Vehicle embodiments include at least two-, three-, four- and six-wheeled vehicles, both transverse and in-line. Additionally, the invention provides a bipedal walking robot. One embodiment provides a robotic mule--a payload-carrying vehicle. The invention combines the flexible mobility of bipedal vehicles with the stability and functionality of very large-wheeled vehicles. Additionally, a bimodal conveyance mechanism readily converts between walking and rolling modes.</p> <p>Gray water interface valve systems and methods: embodiments of the present invention provide systems and methods for a gray water interface valve for use with a vacuum source and a collection tank. The systems and methods comprise a basin for collecting gray water, the basin having an outlet; a reservoir in fluid communication with the outlet, the reservoir adapted to house gray water; a vent line associated with the reservoir; a pressure switch associated with the reservoir, the pressure switch adapted to signal when the reservoir is full; a controller associated with the pressure switch, the controller adapted to begin a discharge cycle by checking and switching on the vacuum source if necessary; a solenoid valve activated by the controller in order to control the flow of vacuum through the system; and a drain valve adapted to open via vacuum pressure and evacuate gray water from the reservoir, wherein the drain valve is adapted to close before all of the gray water from the reservoir is emptied to reduce noise.</p> <p>Air-blower tidal power generation device: An air-blower tidal power generation device includes a rack, an air-blower mechanism, and a power generation mechanism. The air-blower mechanism includes a pumping device, a buoy, and an air conduit. The pumping device includes a cylinder and a stationary barrel movably coupled together. The power generation mechanism includes a constant-pressure and pressure-regulation device and a power generator having an air-driven turbine. Thus, tides move the buoy up and down to drive the pumping device for cyclically drawing and pumping air, and the air is preserved in the constant-pressure and pressure-regulation device to provide a constant pressure for subsequent and stable supply of airflow to the turbine for driving the power generator to generate power.</p>
41	2013b	Fu, et al.	<p>Design a device to collect energy from human motion for use in developing and impoverished rural communities.</p> <ul style="list-style-type: none"> • Used by low power draw electrical devices • Provide energy to be stored in a rechargeable battery with approximately 80% efficiency • low cost • easy to maintain <p>Wave operated power apparatus: an elongated U-shaped pipeline has floats pivoted on transverse axes for rocking thereon in response to wave action in water which the floats are buoyant. Rocking of the floats operates pumps arranged in pressure compounding relation and the fluid under pressure is delivered to a shore-based storage tank. The storage tank being sealed allows build up of a pressure head. The fluid is let out through a regulator to operate machinery. Spent fluid from the plant is spilled out into a recovery tank, directly under the motor or turbine. It is then picked up by the lower leg of the pipeline and returned to repeat its cycle again. The floats support the pipeline and can be flooded to sink below the surface to avoid damage by storm waves.</p>

				<p>System for recovering wasted energy from IC engine: An internal combustion engine and its method of operation including at least one embodiment operating on a six-stroke cycle and including at least one piston and cylinder assembly. The six-stroke cycle includes two power strokes, the latter of which is the result of a water to steam conversion process utilizing the heat of the exhaust gas from the first power stroke. A second embodiment comprises a hybrid power generating assembly incorporating alternative, first and second power sources respectively comprising an internal combustion engine and a water injection engine, the latter of which operates on the water to steam conversion process, wherein the required heat therefore is derived from the exhaust gas of the internal combustion engine. Another preferred embodiment comprises the utilization of different normally wasted heat sources from an IC engine for the generation of sufficient work energy to drive a power take-off, such as hybrid drive assembly.</p> <p>Method and device for capture, storage, and recirculation of heat energy: A heat generation and storage device supplements building heating and hot water systems. A roof cap including an air passage is connected to air outlets disposed within the roof structure of a building and to air passages formed by panels mounted over the surface of a building's roof. The roof cap is connected to a vent which either exhausts air to the atmosphere and/or recirculates air to a liquid heat storage tank. Heated air and heated water from the storage tank supplement a building's heating and hot water systems.</p> <p>Water current powered motor: a water powered motor for extracting raw energy from a water current and converting it to kinetic energy. The water powered motor is generally rectangular in shape with a generally round water wheel consisting of foldable vanes. The vanes receive raw energy produced by water current transforming that raw energy into usable energy for powering a pump, electric generator or as a general power source to power other equipment such as desalinization machinery.</p>
42	2014	Agogue, et al.	Design a device to ensure that a hen's egg dropped from a height of 10 m does not break	Idea of freezing the egg before dropping it
43	2014	Agogue, et al.	Design a device to ensure that a hen's egg dropped from a height of 10 m does not break	Idea of slowing the fall with a parachute
Studies Presenting Negative Examples				
44	1991	Jansson & Smith	<p>Design a car-mounted bicycle rack</p> <ul style="list-style-type: none"> • Easy mounting of the bicycle • Easy mounting of the rack • Cannot harm bike or car • Must be versatile for all bikes and cars 	<p>The bicycle is set in the rails and the vinyl coated hook is attached to the seat tube of the bike, and then the hook is tightened down by hand with a wing nut. One should note the difficulty of mounting the middle bikes on the rack.</p> 
45	1991	Jansson & Smith	<p>Design a measuring cup for the blind</p> <ul style="list-style-type: none"> • Easy operation by the blind • Use for powders and liquids • Prevent waste of food products • Graduate from ¼ to 2 cups • No splatter during operation • Easy to clean • Inexpensive 	<p>8 individual compartments of ¼ cup An audible "click" for each compartment</p> 

46	1991	Jansson & Smith	<p>Design a disposable spillproof coffee cup</p> <ul style="list-style-type: none"> • Operable with one hand • Durable • No straws or mouthpiece 	
47	1991	Jansson & Smith	<p>Design a device to measure speed and pressure</p>	<p>Device to measure speed and pressure</p>
48	1993	Purcell, Williams, Gero, & Colbron	<p>Design a measuring cup for the blind</p> <ul style="list-style-type: none"> • Easy operation by the blind • Use for powders and liquids • Prevent waste of food products • Graduate from $\frac{1}{4}$ to 2 cups • No splatter during operation • Easy to clean <p>Inexpensive</p>	
49	1993	Purcell, Williams, Gero, & Colbron	<p>Design a measuring cup for the blind</p> <ul style="list-style-type: none"> • Easy operation by the blind • Use for powders and liquids • Prevent waste of food products • Graduate from $\frac{1}{4}$ to 2 cups • No splatter during operation • Easy to clean <p>Inexpensive</p>	
50	1993	Purcell, Williams, Gero, & Colbron	<p>Design a measuring cup for the blind</p> <ul style="list-style-type: none"> • Easy operation by the blind • Use for powders and liquids • Prevent waste of food products • Graduate from $\frac{1}{4}$ to 2 cups • No splatter during operation • Easy to clean <p>Inexpensive</p>	
51	1993	Purcell, Williams, Gero, & Colbron	<p>Design a measuring cup for the blind</p> <ul style="list-style-type: none"> • Easy operation by the blind • Use for powders and liquids • Prevent waste of food products • Graduate from $\frac{1}{4}$ to 2 cups • No splatter during operation • Easy to clean <p>Inexpensive</p>	
52	2005	Chrysikou & Weisberg	<p>Design a car-mounted bicycle rack</p> <ul style="list-style-type: none"> • Easy mounting of the bicycle 	<p>The bicycle is set in the rails and the vinyl coated hook is attached to the seat tube of the bike, and then the hook is tightened down by hand with a wing nut. One should note the difficulty of mounting the middle bikes on the rack.</p>

			<ul style="list-style-type: none"> • Easy mounting of the rack • Cannot harm bike or car • Must be versatile for all bikes and cars 		
53	2005	Chrysikou & Weisberg	Design a disposable spillproof coffee cup <ul style="list-style-type: none"> • Operable with one hand • Durable • No straws or mouthpiece 		
54	2009	Hassard, Blandford, & Cox	Design a car-mounted bicycle rack <ul style="list-style-type: none"> • Easy mounting of the bicycle • Easy mounting of the rack • Cannot harm bike or car • Must be versatile for all bikes and cars 		<p>The bicycle is set in the rails and the vinyl coated hook is attached to the seat tube of the bike, and then the hook is tightened down by hand with a wing nut. One should note the difficulty of mounting the middle bikes on the rack.</p>
55	2009	Hassard, Blandford, & Cox	Design a disposable spillproof coffee cup <ul style="list-style-type: none"> • Operable with one hand • Durable • No straws or mouthpiece 		
56	2013a	Viswanathan & Linsey	Design a digital music player and a medicine dispenser problem Design a device to shell peanut (low cost and easy to manufacture)		<p>Flawed example</p>

57	2013a	Viswanathan & Linsey	Design a device to shell peanut (low cost and easy to manufacture)	
58	2013a	Viswanathan & Linsey	Design a device to shell peanut (low cost and easy to manufacture)	
59	2013a	Viswanathan & Linsey	Design a device to shell peanut (low cost and easy to manufacture)	