May 1, 2013

1. For electrical systems, power (in Watts) is current (in Amps) times voltage (in Volts). If a battery supplies 2 Amps at 12 Volts, how much power is this?

   (a) 2/12 = 0.1666 W
   (b) 2 W
   (c) 6 W
   (d) 12 W
   (e) 24 W

2. Four PV panels are hooked in series (voltages add, current is common to all), so the composite I-V curve has a “knee” at 60 V for a current of 8 A. What is the power of the composite?

   (a) 7.5 W
   (b) 60 W
   (c) 120 W
   (d) 480 W
   (e) impossible to say with these numbers

3. True or False: The energy it takes to fabricate a photovoltaic panel is never recovered in its lifetime of use, so making PV panels is a net energy loser?

   (a) True
   (b) False

4. If a system costs $4 per peak Watt, (after rebates, say) and you need a peak capacity of 2kW, how much will your PV system cost?

   (a) $8
   (b) $800
   (c) $4000
   (d) $8000
   (e) $16000

5. If the system on average delivers 1/4 the peak power (day/night, seasons, weather), or 500 W average, how many kWh per day will you typically get?

   (a) 500 kWh
   (b) 0.5 kWh
   (c) 12,000 kWh
   (d) 12 kWh
   (e) 24 kWh

6. At 12 kWh per day, and electricity at $0.15 per kWh, how much does your system save you on your electricity bill?

   (a) about $12\times\$0.15$ = $1.80 per month
   (b) about $12\times\$0.15\times30$ = $54 per month
   (c) about $12\times\$0.15\times30$ = $54 per year
   (d) about $12\times\$0.15\times365$ = $657 per year

7. Let's say your system saves you $667 per year. How long to pay off the $8,000 investment?

   (a) 6.7 years
   (b) 8 years
   (c) 12 years
   (d) 16 years

May 8, 2013

8. We've seen that photovoltaic systems of modest size can easily provide the electricity needs of a household. Why should we still worry about energy availability?

   (a) Because electricity use in homes is a small part of the total energy use
   (b) Because photovoltaics will never be cheaper than fossil fuels
   (c) Because photovoltaics don't directly address transportation needs
   (d) Because PVs cost more energy to make than they ever produce

9. What is wrong with the phrase: "consumes no more energy than a hairdryer"?

   (a) a car produces motion, but a hairdryer heat
   (b) neither consume energy: they just transform energy
   (c) one is solar energy, the other electrical
   (d) what they mean is power: energy from a hair dryer depends on time used
   (e) I wouldn't be caught dead driving a hair dryer around town

May 10, 2013

10. What if you had a concentrating solar thermal collector operating at 530°C ($\sim$800 K) and used it to run a heat engine venting to 27°C (300 K). What would be it's maximum possible efficiency?

   (a) 300/800 = 38%
   (b) 500/530 = 94%
   (c) 500/800 = 63%
   (d) 27/530 = 5%
   (e) 800/500 = 160%

11. If, as a toy example, only 80% of incident light hits the black collector, 50% of this stays on the collector, and 75% of this makes it into the water, what is the net efficiency of heating the water?

    (a) 30%
    (b) 37.5%
    (c) 40%
    (d) 50%
    (e) 75%

12. If you pay $1.50 per day for hot water, and a solar system costs $6,000, how long will it take to break even?

    (a) 400 days $\approx$ 1 yr
    (b) 600 days $\approx$ 1.6 yrs
    (c) 4000 days $\approx$ 11 yrs
    (d) 6000 days $\approx$ 16 yrs

May 13, 2013

13. If each person in the U.S. is responsible for 10,000 W (10^4 W) of power, and there are 300 million people (3×10^8) in the U.S., and the U.S. uses 25% of the world power, what is the total global power production?

    (a) 1.2×10^{12} W
    (b) 3×10^{12} W
    (c) 12×10^{12} W
    (d) 20×10^{12} W

14. Since almost all human power production happens on land, but only 50% of the global photosynthetic process happens on land, which is bigger on land: human or plant power?

    (a) human is way bigger
    (b) human is bigger by a bit
    (c) plant is bigger by a bit
    (d) plant is way bigger

15. How much energy can be released if one cubic meter of water (mass 1,000 kg) drops 10 meters?

    (a) 100 J
    (b) 1,000 J
    (c) 10,000 J
    (d) 100,000 J

(e) 1,000,000 J

16. If each cubic meter of water in a 10 meter dam contains 100,000 J of gravitational potential energy, how much power is released by a 20 meter dam with a flow of 1,000 m^3/s?

    (a) 100,000 J/s = 100 kW
    (b) 200,000 J/s = 200 kW
    (c) 100,000,000 J/s = 100 MW
    (d) 200,000,000 J/s = 200 MW
    (e) 2,000,000,000 J/s = 2 GW

17. Given numbers we covered from this lecture, what is the maximum hydroelectric contribution to our energy budget if 100% developed?

    (a) 3%
    (b) 6%
    (c) 25%
    (d) 50%
    (e) we could get all of it this way

May 15, 2013

18. Let's say you've designed a wind farm capable of 800 MW of power production when the wind gets to 20 m/s. If the average wind available is 10 m/s, what is the power achieved in an average wind?

    (a) 800 MW
    (b) 400 MW
    (c) 200 MW
    (d) 100 MW
    (e) 50 MW

19. S.D. has about 200 W/m^2 of both wind and solar. PV can get 10% easily; wind can get 1.5% area coverage, and 40% efficiency. Do you get more power by covering an acre with PV or wind turbines?

    (a) wind does better, no question
    (b) wind does slightly better
    (c) solar does slightly better
    (d) solar does better, no question

20. If solar is so much better than wind, why is wind growing so much faster than solar?

    (a) It is cheaper to fill an acre of land with windmills than with PV
    (b) Wind is more reliable: constant, even at night

(c) Government subsidies heavily favor wind

(d) The payback time for wind is shorter than for PV

(e) The average cost per kWh is cheaper for wind

21. Why is biomass considered exempt from CO_2 emissions regulations?

    (a) because biomass does not emit CO_2 when burned

    (b) because there is very little CO_2 involved

    (c) because the CO_2 is borrowed and returned to the air

    (d) because governments want to encourage development of biofuels, and not hamper with regulation

    (e) because there is not enough of it presently to be a concern

22. Try to guess the efficiency of photosynthesis (as implemented in real plants).

    (a) 0.1%

    (b) 2%

    (c) 10%

    (d) 50%

    (e) 80%

May 17, 2013

23. If a corn field is 1.5% efficient, and an acre is 4000 m^2, and the average insolation is 200 W/m^2, how much power does an acre of corn produce/store?

    (a) 3 W/m^2

    (b) 60 W

    (c) 1200 W

    (d) 12,000 W

    (e) 800,000 W

24. If we harvest 80 QBtu of biomass today, and our budget is 100 QBtu, does this mean we can transition entirely to bio?

    (a) Yes: if we just cut back a bit on expenditure

    (b) Yes: we can probably ramp this up to 100 QBtu

    (c) Maybe: seems too close to call

    (d) No: we can't convert that 80 QBtu at high efficiency

    (e) No: we would then starve for lack of food

25. If corn ethanol had come out to 1.5:1 energy return:invested, then what percentage of the *harvested* energy do we effectively get to keep (divert to other uses)?

(a) 33%
(b) 50%
(c) 60%
(d) 67%
(e) 150%

May 20, 2013

26. A neutron decays. It has no electric charge. If a proton (positive charge) is left behind, what other particle must come out if net charge is conserved?

    (a) no other particles are needed
    (b) a negatively charged particle must emerge as well
    (c) a positively charged particle must emerge as well
    (d) another charge will come out, but it could be either + or -
    (e) neutrons cannot exist individually

27. If a neutron mass is 1.008665 amu, and the left-over kinetic energy after decay is 0.000841 amu, what percentage of the total mass-energy is left as kinetic energy?

    (a) 8.4%
    (b) 0.84%
    (c) 0.084%
    (d) 0.0084%
    (e) 0.00084%

28. If one of the neutrons in carbon-14 (carbon always has 6 protons) decays into a proton, what nucleus is left?

    (a) carbon-13, with 6 protons, 7 neutrons
    (b) carbon-14, but with 7 protons, 7 neutrons
    (c) boron-14, with 5 protons, 9 neutrons
    (d) nitrogen-14, with 7 protons, 7 neutrons
    (e) nitrogen-15, with 7 protons, 8 neutrons

29. If a substance has a half-life of 30 years, how much will be left after 90 years?

    (a) one-half
    (b) one-third
    (c) one-fourth
    (d) one-sixth
    (e) one-eighth

30. If you have a bone fragment that, when living, had one ^{14}C atom for every 100 million carbon atoms, how old is the bone if there is one ^{14}C for every 400 million carbons, if half-life is about 6,000 years?

    (a) 6,000 years
    (b) 12,000 years
    (c) 18,000 years
    (d) 24,000 years
    (e) age cannot be inferred this way

31. Where did the uranium we use for nuclear energy come from?

    (a) generated in the Big Bang
    (b) generated in supernova explosions of earlier stars
    (c) generated slowly over billions of years in other stars
    (d) generated by our own Sun and transferred to the Earth
    (e) not original to Earth, but result of radiactive decays within

May 22, 2013

32. What is the best summary of how a nuclear reactor works?

    (a) radioactivity makes source hot (thermally), which boils water for steam
    (b) radioactive decay products (electrons, mostly) are harnessed to produce electricity
    (c) spare neutrons decay, releasing energy
    (d) the fragment nuclei are together *more* massive than the original nucleus, and this mass change releases energy

33. If one gram of ^{235}U produces about 60 GJ of energy upon fission, a 1 GW plant goes through how many grams of ^{235}U per minute?

    (a) about 0.1 grams
    (b) about 1 gram
    (c) about 10 grams
    (d) about 100 grams
    (e) about 1 kilogram

34. But if only a third of the thermal energy is converted into useful electricity, and the plant actually delivers 1 GWe of electricity, how many grams per minute are used?

    (a) still 1 gram per minute
    (b) about 3 grams per minute
    (c) about 10 grams per minute
    (d) about 33 grams per minute

(e) I give up

35. At 3 grams per minute, and 1440 minutes in a day, about 4 kg of ^{235}U nuclei split in a day. If 100,000 kg of 4%–enriched uranium are loaded into the reactor, how long could the reactor run?

    (a) 100 days
    (b) 250 days
    (c) 1000 days
    (d) 2500 days
    (e) 10,000 days

36. How long do you think our uranium supply would last if we went 100% nuclear, using conventional nuclear plants (the kind we use now)?

    (a) 30 years
    (b) 100 years
    (c) 300 years
    (d) 1000 years
    (e) 3000 years

May 24, 2013

37. We saw last time that a 1 GWe nuclear reactor consumes about 4 kg of ^{235}U in a day. Given the 0.7% natural abundance of ^{235}U, how much natural uranium must be mined per day to supply the plant?

    (a) 0.028 kg
    (b) 2.8 kg
    (c) 6 kg
    (d) 60 kg
    (e) 600 kg

38. If the price of natural uranium went up to $250/kg, how much would a day's uranium supply (600 kg) cost?

    (a) $150
    (b) $1,500
    (c) $15,000
    (d) $150,000
    (e) $1,500,000

39. If an electrical plant must *produce* electricity at a cost of $0.05/kWh in order to be competitive, what daily production cost does this translate to, running 1 GWe continuously over 24 hours?

(a) \$120,000,000
(b) \$12,000,000
(c) \$1,200,000
(d) \$120,000
(e) \$12,000

40. Putting the pieces together, what fraction of the nuclear plant's operation is in raw fuel material (does not include enrichment)?

(a) around 0.1–0.15%
(b) around 1–1.5%
(c) around 10–15%
(d) nearly the entire cost
(e) way more than the cost threshold

May 29, 2013

41. Clean energy; the source is all around us; ample enough to easily match our needs; will last for many millions of years. Besides fusion, what does this sound like?

(a) Oil
(b) Solar
(c) Geothermal
(d) Nuclear fission
(e) Wind

42. If the wiggles on the Keeling Curve are due to photosynthesis, in which season do you think it's at the high point of the wiggle (most CO_2 in the air)?

(a) Northern hemisphere winter
(b) Northern hemisphere spring
(c) Northern hemisphere summer
(d) Northern hemisphere fall

43. The outbound radiation from the surface is 390 W/m^2, and the inbound from the cool sky is 150 W/m^2. What makes the 240 W/m^2 difference?

(a) water condensation
(b) sun (insolation average of non-reflected light)
(c) air currents
(d) storms (big energy deposition)
(e) none of these sound right

44. If we have only spent half our recoverable fossil fuels at this point, and have seen atmospheric CO_2 climb from 280 ppm to 400 ppm, how much higher should we expect the CO_2 level to climb?

(a) it should saturate (stay the same) at today's value

(b) it will double: 380 $\rightarrow$ 760 ppm

(c) the pre-industrial level of 280 will double $\rightarrow$ 560 ppm

(d) it will rise another 120 ppm $\rightarrow$ 520 ppm

(e) there is no basis for extrapolation

45. When the earth gets hotter, the power radiated, σT^4 shoots up. What kind of feedback does this create?

(a) This is not pertinent to feedback

(b) Positive feedback: hotter $\rightarrow$ more radiation $\rightarrow$ heating influence

(c) Positive feedback: hotter $\rightarrow$ more radiation $\rightarrow$cooling influence

(d) Negative feedback: hotter $\rightarrow$ more radiation $\rightarrow$ cooling influence

(e) Negative feedback: hotter $\rightarrow$ more radiation $\rightarrow$ heating influence

May 31, 2013

46. If you as a citizen of the U.S. use 10,000 W continuously (about 10^9 J or ~200,000 kcal per day), how much mass of fuel are you responsible for on a daily basis if your fuel is 10 kcal/gram?

(a) 2 kg

(b) 20 kg

(c) 200 kg

(d) 2000 kg

(e) 20,000 kg

47. At 10,000 W, and about 8,000 W from fossil fuels (about 2 kcal/sec), "you" run through about 0.2 grams of fossil fuel per second, or 6 tons per year. How many tons of CO_2 do "you" generate per year?

(a) 6 kg, which is almost negligible

(b) 18 kg

(c) 6 tons

(d) 18 tons

(e) depends strongly on the type of fuel and efficiency of use

48. If we sequestered the CO_2 into, say, $CaCO_3$ (like concrete), each 44 g of CO_2 becomes 100 g of "rock." The 400 tons of CO_2 you've "made" in your lifetime would become 1000 tons of "rock." At 2.5 tons per cubic meter, how many cubic meters does this occupy?

(a) 0.4 m^3
(b) 1 m^3
(c) 4 m^3
(d) 10 m^3
(e) 400 m^3

49. By the time you are twice your current age, you will have required 800 m^3 of $CaCO_3$. How big is the cube that contains this?

(a) 3 meters on a side
(b) 9 meters on a side
(c) 20 meters on a side
(d) 80 meters on a side
(e) 800 meters on a side

June 5, 2013

50. Do you know: how bright is a 100 W incandescent light bulb?

(a) 15 lumens
(b) 100 lumens
(c) 500 lumens
(d) 1500 lumens
(e) lu-what?

51. Which kind of bulb (equivalent brightness) do you think costs the **most** (price of bulb and cost of electricity) over a fixed period of time?

(a) incandescent bulb
(b) compact fluorescent bulb (CFL)
(c) LED bulb
(d) they're all about the same
(e) two of them are tied

52. What lighting level is useful for a lamp in a room, roughly?

(a) 15 lumens
(b) 100 lumens
(c) 800 lumens
(d) 2000 lumens
(e) inappropriate units/choices

53. If driving 100 miles costs \$9 for gasoline and \$5 for electricity, how much money do you save during the lifetime of the car/battery (assuming prices stay the same)?

(a) a few hundred dollars
(b) about $1,000
(c) about $5,000
(d) about $15,000
(e) the problem lacks information

54. If you save $5000 in propulsion cost, but have to replace the battery at that time, what is the maximum range you can support without losing money overall (assume $500/kWh battery cost and about 30 kWh/100 mi)?

(a) 5 kWh → 17 miles
(b) 10 kWh → 33 miles
(c) 20 kWh → 67 miles
(d) 30 kWh → 100 miles
(e) 100 kWh→300 miles

Answer Key: 1. e; 2. d; 3. b; 4. d; 5. d; 6. b or d; 7. c; 8. a or c; 9. d; 10. c; 11. a; 12. c; 13. c; 14. c; 15. d; 16. d; 17. b; 18. d; 19. d; 20. a, d, or e; 21. c; 22. a or b; 23. d; 24. c or e; 25. a; 26. b; 27. c; 28. d; 29. e; 30. b; 31. b; 32. a; 33. b; 34. b; 35. c; 36. a (maybe b); 37. e; 38. d; 39. c; 40. c; 41. b; 42. a or b; 43. b; 44. d; 45. d; 46. b; 47. b; 48. e; 49. b; 50. d; 51. a; 52. c; 53. c; 54. b