Core Science 221, Section 1 **NAME:**

Homework 3: Scientific Notation, Energy and Power Units, Some Energy and Power Examples, The R/P Ratio: Homeworks are due as posted on the course web site. Enter the answer to the multiple-choice questions on the answer table beside the number corresponding to the question. There may be gaps in the table when full-answer questions appear in the homework. You only need to hand in the table for the multiple-choice questions. Solutions will be posted eventually after the due date.

Answer Table

Name:

	a	b	c	d	e		a	b	c	d	e
1.	O	O	O	O	O	31.	O	O	O	O	O
2.	O	O	O	O	O	32.	O	O	O	O	O
3.	O	O	O	O	O	33.	O	O	O	O	O
4.	O	O	O	O	O	34.	O	O	O	O	O
5.	O	O	O	O	O	35.	O	O	O	O	O
6.	O	O	O	O	O	36.	O	O	O	O	O
7.	O	O	O	O	O	37.	O	O	O	O	O
8.	O	O	O	O	O	38.	O	O	O	O	O
9.	O	O	O	O	O	39.	O	O	O	O	O
10.	O	O	O	O	O	40.	O	O	O	O	O
11.	O	O	O	O	O	41.	O	O	O	O	O
12.	O	O	O	O	O	42.	O	O	O	O	O
13.	O	O	O	O	O	43.	O	O	O	O	O
14.	O	O	O	O	O	44.	O	O	O	O	O
15.	O	O	O	O	O	45.	O	O	O	O	O
16.	O	O	O	O	O	46.	O	O	O	O	O
17.	O	O	O	O	O	47.	O	O	O	O	O
18.	O	O	O	O	O	48.	O	O	O	O	O
19.	O	O	O	O	O	49.	O	O	O	O	O
20.	O	O	O	O	O	50.	O	O	O	O	O
21.	O	O	O	O	O	51.	O	O	O	O	O
22.	O	O	O	O	O	52.	O	O	O	O	O
23.	O	O	O	O	O	53.	O	O	O	O	O
24.	O	O	O	O	O	54.	O	O	O	O	O
25.	O	O	O	O	O	55.	O	O	O	O	O
26.	O	O	O	O	O	56.	O	O	O	O	O
27.	O	O	O	O	O	57.	O	O	O	O	O
28.	O	O	O	O	O	58.	O	O	O	O	O
29.	O	O	O	O	O	59.	O	O	O	O	O
30.	O	O	O	O	O	60.	O	O	O	O	O

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003 qmult 00120 1 3 3 easy math: sci-not. multiplication

Extra keywords: EPS

1. What is $3.0 \times 10^7 \times 7.0 \times 10^3$?

   a) 21×10^{11}. b) 2.1×10^{10}. c) 2.1×10^{11}. d) 3×10^{10}. e) 7×10^4.

SUGGESTED ANSWER: (c)

Behold:

$$3.0 \times 10^7 \times 7.0 \times 10^3 = 21 \times 10^{7+3} = 21 \times 10^{10} = 2.1 \times 10^{11} \ .$$

Wrong answers:

a) You may have forgotten to move the decimal place over.

Redaction: Jeffery, 2008jan01

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003 qmult 00130 1 3 4 easy math: sci-not. division

Extra keywords: EPS

2. What is $(6.0 \times 10^7)/(2.0 \times 10^{14})$?

   a) 1.2×10^{22}. b) 1.2×10^{21}. c) 12.0×10^{21}. d) 3.0×10^{-7}. e) 3.0×10^7.

SUGGESTED ANSWER: (d)

Wrong answers:

a) You have multiplied and not divided.

Redaction: Jeffery, 2008jan01

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003 qmult 00220 1 4 1 easy deducto-memory: megajoule

Extra keywords: EPS

3. "Let's play *Jeopardy*! For \$100, the answer is: A megajoule."

   What is ____________, Alex?

   a) 10^6 J b) 10^{-6} J c) 10^3 J d) 10^9 J e) 10^{24} J

SUGGESTED ANSWER: (a)

Wrong answers:

b) This is a microjoule.
c) This is a kilojoule.
d) This is a gigajoule.
d) This is a yotajoule.

Redaction: Jeffery, 2008jan01

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003 qmult 00230 1 4 5 easy deducto-memory: decimeter scale

Extra keywords: EPS guinea pig

4. "Let's play *Jeopardy*! For \$100, the answer is: It is a creature whose size scale is of order a decimeter."

   What is a/an ____________, Alex?

   a) human b) wolf c) blue whale d) E. coli bacterium e) guinea pig

SUGGESTED ANSWER: (e)

Wrong answers:

c) These guys have lengths up to about 30 m. I originally had the Etruscan shrew here. But Etruscan shrews are a third or more of decimeter and guinea pigs are 2 to 2.5 decimeters. So the question had arguably two right answers since both animals were of order a decimeter though at the opposite ends of the order of scale.
d) These guys are of order micron scale.

Redaction: Jeffery, 2008jan01

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003 qmult 00240 2 5 3 moderate deducto-memory: 1000 food calories

Extra keywords: EPS

5. The food calorie is a weird unit. **1 FOOD CALORIE** is actually 1000 calories or 1 kcal. Now **1000 FOOD CALORIES** is about:

   a) 4 J. b) 4 kJ. c) 4 MJ. d) 4 ZJ. e) 4 YJ.

   SUGGESTED ANSWER: (c)

   Wrong answers:

   a) Really small. Just think lifting a 1 kg mass 1 meter takes about 10 J to put into gravitational potential energy and a 1000 food calories is about half of what sedentary person needes in a day. Even a very sedentary person does a lot more lifting than 1 kg by 1 m.

   c) A yotajoule is 10^{24} J. World total commercial energy usage for a year is only of order 0.0005 YJ.

   Redaction: Jeffery, 2008jan01

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003 qmult 00320 1 5 3 easy deducto-memory: horsepower

Extra keywords: EPS

6. What is 1 electrical horsepower in SI units? **HINT:** Think about light bulb power or small household electrical motor power.

   a) 746 cW. b) 7.46 W. c) 746 W. d) 746 MW. e) 746 GW.

   SUGGESTED ANSWER: (c)

   Wrong answers:

   a) This is 7.46 W. Small household appliances need more than this and you think a horse can only to that much. My electrical pencil sharpner uses 240 W. I suspect it isn't very efficient and a lot of energy goes into waste heat. The world is waiting for the super-efficient electrical pencil sharpner.

   d) This enough power for about 7×10^6 100-W bulbs. If a horse could do this, our energy problems would be solved. Of course, the horses might take over and feed us oats in feed bags and make us wear baggies in the city streets.

   Redaction: Jeffery, 2008jan01

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003 qmult 00330 2 3 5 moderate math: power per capita

Extra keywords: EPS

7. Circa year 2009, humankind numbered about 6.8 billion and used about 16 TW of commercial power. Approximately what was/is the power per capita?

   a) 0.5 W. b) 2 W. c) 30 W. d) 200 W. e) 2000 W/capita.

   SUGGESTED ANSWER: (e)

   Behold:

$$\frac{\text{Amount}}{\text{Rate}} = \frac{16 \times 10^{12}}{6.8 \times 10^9} \approx 2000\,\text{W/captia} .$$

   Wrong answers:

   a) This is factor of order 100–200 below the demands of an ordinary light bulb.

   Redaction: Jeffery, 2008jan01

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003 qmult 00410 1 1 3 easy memory: biosphere energy

Extra keywords: EPS from the Sun.

8. The overwhelmingly dominant source of energy for the biosphere (entire world of living things on Earth which somewhat patchily envelops the Earth in a thin sheath) is:

   a) geothermal power. b) nuclear power stations. c) solar power. d) thermal power stations. e) horse power.

   SUGGESTED ANSWER: (c)

   Wrong answers:

a) There are some biota in the vicinity of hydrothermal vents (black smokers) in the deep sea that rely heavily on geothermal energy. But at least some of these biota depend on solar energy indirectly. See Wikipedia: Hydrothermal vent.
e) Oh, c'mon.

Redaction: Jeffery, 2008jan01

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003 qmult 00420 1 1 1 easy memory: visible light

9. Visible light is:

a) only a small part of the electromagnetic spectrum.
b) not in the electromagnetic spectrum.
c) is the inverse of the electromagnetic spectrum.
d) is not electromagnetic radiation.
e) only green in color.

SUGGESTED ANSWER: (a)

Wrong answers:
e) Tis the Irish answer.

Redaction: Jeffery, 2008jan01

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003 qmult 00430 1 5 4 deducto memory: solar constant, average insolation
Extra keywords: EPS

10. The solar constant is ____________ on average (and it does not very much from average) and the average insolation is about ____________.

a) 170 $\mathbf{W/m^2}$; 1366.5 $\mathbf{W/m^2}$ b) 170.5 $\mathbf{W/m^2}$; 170 $\mathbf{W/m^2}$ c) 1366.5 $\mathbf{W/m^2}$; 1370 $\mathbf{W/m^2}$
d) 1366.5 $\mathbf{W/m^2}$; 170 $\mathbf{W/m^2}$ e) 1366.5 $\mathbf{MW/m^2}$; 170 $\mathbf{MW/m^2}$

SUGGESTED ANSWER: (d)

Wrong answers:
a) You've got the answers the wrong way around.
e) We'd fry.

Redaction: Jeffery, 2008jan01

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003 qmult 00440 1 4 5 easy deducto-memory: solar/commercial power ratio
Extra keywords: EPS

11. "Let's play *Jeopardy*! For \$100, the answer is: Approximately the ratio of total solar power reaching the Earth's surface to total world commercial power circa year 2008."

What is ____________, Alex?

a) 0.5 b) 2 c) 6 d) 550 e) 5500

SUGGESTED ANSWER: (e) See Smil (2006, p.27).

Wrong answers:
a) As Lurch would say AAAARGH.

Redaction: Jeffery, 2008jan01

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003 qmult 00510 1 4 2 easy deducto-memory: basal metabolic rate
Extra keywords: EPS

12. "Let's play *Jeopardy*! For \$100, the answer is: The rate of energy expended (i.e., power expended) by an animal in a state of complete rest, several hours after the last feeding (about 12 hours for humans) and in a comfortable temperature setting."

What is ____________, Alex?

a) metabolic rate (MR) b) basal metabolic rate (BMR) c) metabolic scope (MS)
d) barometric metabolic rate (BMR) e) Basil Rathbone rate (BRR)

SUGGESTED ANSWER: (e)

Wrong answers:

e) Basil Rathbone (1892–1967) will always be the film Sherlock Holmes. But actually Jeremy Brett (1933-1995) was the real Sherlock Holmes.

Redaction: Jeffery, 2008jan01

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003 qmult 00520 2 5 1 mod. deducto memory: BMR and food power

Extra keywords: EPS

13. For typical humans, BMR is in range ____________ and necessary food power is in the range ____________.

a) 55–90 W; ∼ 100–200 W b) ∼ 100–200 W; 55–90 W c) 55–90 W; ∼ 55–90 W
d) ∼ 100–200 W; 100–200 W e) 1 hp; 2 hp

SUGGESTED ANSWER: (a)

Wrong answers:

b) How can the BMR be greater than the necessary food power.
e) These are too big by factors of order 10.

Redaction: Jeffery, 2008jan01

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003 qmult 00530 2 5 4 mod. deducto memory: metabolic scope

Extra keywords: EPS

14. What animal has the largest sustained metabolic scope?

a) Etruscan shrews. b) Guinea pigs. c) Humans.
d) Canids (i.e., wolves, Cairn terriers, etc.). e) Felids.

SUGGESTED ANSWER: (d)

I wish my source (Smil 2006, p. 47, 61) would specify how long sustained is? But I would guess hours for truly fit specimens in their primes.

Wrong answers:

c) We are only number 2.
e) C'mon, does Fluffy look like she has any metabolic scope at all?

Redaction: Jeffery, 2008jan01

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003 qmult 00550 2 4 2 mod-memory: ethanol energy content

Extra keywords: EPS

15. "Let's play *Jeopardy*! For $100, the answer is: It is approximately the energy content of ethanol (commonly called alcohol in alcoholic beveridges)."

What is ____________, Alex?

a) 3 joules/hectogram b) 3 megajoules/hectogram c) 3 gigajoules/hectogram
d) 3 zetajoules/hectogram e) 3 yotajoules/hectogram

SUGGESTED ANSWER: (b)

The students should remember that humans need of order 8–16 MJ/day and this sets a scale for the energy content of typical servings. A standard US alcolohic drink contains of order 13 grams of ethanol. So if one could metabolize all the ethanol energy one would need at least about 3 hectograms or 23 standard drinks a day to sustain oneself energywise if not otherwise. The author is not sure how much of the quoted energy content of ethanol (Smil 2006, p. 58) is metabolizable. But this discussion reminds of W.C. Fields: "During one of my treks through Afghanistan, we lost our corkscrew. We were compelled to live on food and water for several days."

Wrong answers:

e) A yotajoule is 10^{24} J. World total commercial energy usage for a year is only of order 0.0005 YJ. Strong drink indeed.

Redaction: Jeffery, 2008jan01

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003 qmult 00600 1 5 3 easy deducto-memory: R/P ratio 1
Extra keywords: EPS

16. The resource reserve divided by the production rate of the resource for any resource is called the:

    a) PR quotient. b) PRDBP ratio. c) R/P ratio. d) P/R ratio. e) PR factor.

SUGGESTED ANSWER: (c)

Wrong answers:
e) It has been used that way.

Redaction: Jeffery, 2008jan01

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003 qmult 00620 1 3 5 easy math: R/P for oil
Extra keywords: EPS

17. As of year 2009, the estimated reserve of oil (petroleum) is/was about 1300 Gbl (a Gbl is a gigabarrel). The annual rate of oil production/consumption (circa 2008) is/was about 30 Gbl/year. Approximately what is/was the current estimated R/P ratio for oil?

    a) 1300 years. b) 30 years. c) 1 week. d) 100 years. e) 43 years.

SUGGESTED ANSWER: (e)

For world production oil production, see:

`http://en.wikipedia.org/wiki/World_oil_production` .

For world proved oil reserves, see:

`http://www.eia.doe.gov/emeu/international/reserves.html` .

For the US oil consumption, see:

`http://tonto.eia.doe.gov/dnav/pet/pet_cons_psup_dc_nus_mbbl_a.htm` .

Behold:

$$R/P = \frac{1300}{30} \approx 43\,\text{years} .$$

Wrong answers:
a) We'd have nothing to worry about—except global warming.

Redaction: Jeffery, 2008jan01

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003 qmult 00640 1 3 4 easy math: R/P for coal
Extra keywords: EPS

18. Circa year 2006 the world proved coal reserve amounted to about 9×10^{14} kg. Much more coal probably exists, but not in the proved (i.e., very well verified) deposits. The annual rate of coal production/consumption (circa 2007) is/was about 6×10^{12} kg/year. Approximately what is/was the current estimated R/P ratio for coal?

    a) 9×10^{14} years. b) 6×10^{12} years. c) 6.7×10^{-3} years. d) 150 years. e) 15 years.

SUGGESTED ANSWER: (d)

For world coal production and proved reserves, see

`http://en.wikipedia.org/wiki/Coal_by_country` .

Behold:

$$R/P = \frac{9 \times 10^{14}}{6 \times 10^{12}} = 150\,\text{years} .$$

It is likely that most of this coal will never come out of the ground. For environmental reasons (in particular to reduce global warming), we will probably have moved on to mainly renewable energy resources in the next hundred years or so. At least this is the author's view. But he's just agreeing with his guru Vaclav Smil.

Actually, some people think the expense of extraction will also soon limit coal production. In their view, the peak coal could be circa 2025.

Wrong answers:

a) As Lurch would say AAARRRGH!

Redaction: Jeffery, 2008jan01