Introductory Astronomy **NAME:**

Homework 8: The Sun: Homeworks and solutions are posted on the course web site. Homeworks are **NOT** handed in and **NOT** marked. But many homework problems ($\sim$ 50–70 %) will turn up on tests.

Answer Table

Name:

	a	b	c	d	e		a	b	c	d	e
1.	O	O	O	O	O	37.	O	O	O	O	O
2.	O	O	O	O	O	38.	O	O	O	O	O
3.	O	O	O	O	O	39.	O	O	O	O	O
4.	O	O	O	O	O	40.	O	O	O	O	O
5.	O	O	O	O	O	41.	O	O	O	O	O
6.	O	O	O	O	O	42.	O	O	O	O	O
7.	O	O	O	O	O	43.	O	O	O	O	O
8.	O	O	O	O	O	44.	O	O	O	O	O
9.	O	O	O	O	O	45.	O	O	O	O	O
10.	O	O	O	O	O	46.	O	O	O	O	O
11.	O	O	O	O	O	47.	O	O	O	O	O
12.	O	O	O	O	O	48.	O	O	O	O	O
13.	O	O	O	O	O	49.	O	O	O	O	O
14.	O	O	O	O	O	50.	O	O	O	O	O
15.	O	O	O	O	O	51.	O	O	O	O	O
16.	O	O	O	O	O	52.	O	O	O	O	O
17.	O	O	O	O	O	53.	O	O	O	O	O
18.	O	O	O	O	O	54.	O	O	O	O	O
19.	O	O	O	O	O	55.	O	O	O	O	O
20.	O	O	O	O	O	56.	O	O	O	O	O
21.	O	O	O	O	O	57.	O	O	O	O	O
22.	O	O	O	O	O	58.	O	O	O	O	O
23.	O	O	O	O	O	59.	O	O	O	O	O
24.	O	O	O	O	O	60.	O	O	O	O	O
25.	O	O	O	O	O	61.	O	O	O	O	O
26.	O	O	O	O	O	62.	O	O	O	O	O
27.	O	O	O	O	O	63.	O	O	O	O	O
28.	O	O	O	O	O	64.	O	O	O	O	O
29.	O	O	O	O	O	65.	O	O	O	O	O
30.	O	O	O	O	O	66.	O	O	O	O	O
31.	O	O	O	O	O	67.	O	O	O	O	O
32.	O	O	O	O	O	68.	O	O	O	O	O
33.	O	O	O	O	O	69.	O	O	O	O	O
34.	O	O	O	O	O	70.	O	O	O	O	O
35.	O	O	O	O	O	71.	O	O	O	O	O
36.	O	O	O	O	O	72.	O	O	O	O	O

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001 qmult 00007 1 4 1 easy deducto-memory: reading done 2

1. Did you complete reading the Introductory Astronomy Lecture before the **SECOND DAY** on which the lecture was lectured on in class?

   a) YYYessss! b) Jawohl! c) Da! d) Sí, sí. e) OMG no!

   SUGGESTED ANSWER: (a),(b),(c),(d)

   Wrong answers:
   e) As Lurch would say AAAARGH.

   Redaction: Jeffery, 2008jan01

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008 qmult 00200 1 4 3 easy deducto-memory: Sun diameter

2. The diameter of the Sun is about:

   a) 1 Earth diameter. b) 30 Earth diameters. c) 109 Earth diameters. d) 1 astronomical unit. e) 1 light-year.

   SUGGESTED ANSWER: (c) Ni-117 gives 109 Earth diameters and that sounds about right.

   Wrong answers:
   a) This would make the Sun the same size as the Earth.
   d) This would make the Sun's surface extend right to Earth's orbit.

   Redaction: Jeffery, 2001jan01

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008 qmult 00220 1 4 3 easy deducto-memory: solar luminosity

Extra keywords: CK-262,266

3. The solar luminosity is $L_\odot$ is:

   a) 100 W. b) 3.846×10^{-26} W. c) 3.846×10^{26} W. d) 1.496×10^{11} m.
   e) 6.9599×10^{8} m.

   SUGGESTED ANSWER: (c)

   Wrong answers:
   a) An incandescent light in your room has the same luminosity as the Sun.
   d) This is the astronomical unit. The meter unit should be a clear giveaway.
   e) This is the solar radius to the photosphere. The meter unit should be a clear giveaway.

   Redaction: Jeffery, 2001jan01

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008 qmult 00230 1 1 5 easy memory: Sun photosphere temperature

4. The temperature of the solar photosphere is about:

   a) 300 K. b) 600 K. c) 273 K. d) 40000 K. e) 6000 K.

   SUGGESTED ANSWER: (e)

   Wrong answers:
   c) This is the freezing temperature of water.

   Redaction: Jeffery, 2001jan01

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008 qmult 00250 1 4 4 easy deducto-memory: solar constant defined

5. "Let's play *Jeopardy*! For $100, the answer is: It is the electromagnetic radiation energy per unit time per unit area from the Sun at 1 astronomical unit from the Sun."

   What is the solar _____, Alex?

   a) wind b) variable c) eclipse d) constant e) Sun

   SUGGESTED ANSWER: (d)

   Wrong answers:
   b) Since the solar constant does actually vary a bit, "solar variable" might be a better name.

e) As Lurch would say: "Aaaarh."

Redaction: Jeffery, 2001jan01

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008 qmult 00252 1 1 1 easy memory: solar constant value

6. The solar constant (i.e., the electromagnetic radiation energy per unit time per unit area from the Sun at 1 astronomical unit from the Sun) is:

a) $1367.6\,\mathrm{W/m^2}$. b) $1000.00\,\mathrm{W/m^2}$. c) 0. d) $-1367.6\,\mathrm{W/m^2}$. e) infinite.

SUGGESTED ANSWER: (a)

Wrong answers:

b) Doesn't this seem suspiciously round and precise for a physical variable that has not be defined to be round and precise.

e) As Lurch would say: "Aaaarh."

Redaction: Jeffery, 2001jan01

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008 qmult 00256 2 5 5 moderate thinking: solar constant and light bulbs

7. The solar constant (i.e., the electromagnetic radiation energy per unit time per unit area from the Sun at 1 astronomical unit from the Sun) is about 1367.6 watts per square meter. If you were at 1 astronomical unit from the Sun in space and had a square kilometer of solar panels (of 100 % efficiency), how many 100 watt light bulbs could you run on solar power?

a) 100 watts. b) 1000. c) 1367.6. d) 1.3676×10^{11}. e) 1.3676×10^{7}.

SUGGESTED ANSWER: (e)

Behold:

$$1367.6\,\mathrm{W/m^2} \times \left(\frac{10^3\,\mathrm{m}}{1\,\mathrm{km}}\right)^2 \left(\frac{1\,\text{light bulb}}{100\,\mathrm{W}}\right) = 1.3676 \times 10^7\,\text{light-bulbs/km}^2\ .$$

Wrong answers:

a) Wrong number, wrong units.

d) This is obtained by multiplying by 100, not dividing by 100.

Redaction: Jeffery, 2001jan01

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008 qmult 00300 1 4 5 easy deducto-memory: interior of Sun specified

Extra keywords: CK-263,267-4

8. "Let's play *Jeopardy*! For $100, the answer is: This astrophysical body has three main interior layers: 1) a core (in which thermonuclear reactions occur) that extents out to about 25 % of the body's radius; 2) a radiative transfer zone which extends **OUT** to about 71 % of the body's radius; 3) a convective zone that extends **FROM** about 71 % of the body's radius to the body's surface."

What is _____, Alex.

a) the Moon b) Venus c) the Milky Way d) the Earth e) the Sun

SUGGESTED ANSWER: (e) See Cox-342.

Wrong answers:

a) No. It's not the Moon.

Redaction: Jeffery, 2001jan01

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008 qmult 00310 1 4 3 easy deducto-memory: radiative transfer in Sun

9. Out to about 71 % of the Sun's radius, the dominant energy transfer mechanism is:

a) electron conduction. b) neutrino transfer. c) radiative transfer (i.e., transfer by electromagnetic radiation). d) convection. e) an explosive shock wave.

SUGGESTED ANSWER: (c) This is energy transfer by EMR. Cox-342 and CM-243 say 71 % which agrees with older references.

Wrong answers:
a) This is important in metals.
b) This is important during the core collapse phase of supernovae
e) This is important during the explosion phase of supernovae.

Redaction: Jeffery, 2001jan01

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008 qmult 00410 1 1 5 easy memory: solar photosphere explained
Extra keywords: this question is specialized for the Sun
10. Why can't we see deeper into the Sun than the photosphere?

a) Line spectra overlap too severely at deeper layers.
b) The question is absurd. We see right through the photosphere to the bottom of the convection layer.
c) The question is absurd. Solar flares prevent any observation deeper than the chromosphere.
d) Radiation from deeper layers escapes too easily.
e) Radiation from deeper layers is absorbed before it can escape the Sun.

SUGGESTED ANSWER: (e) The students should know the answer even if they don't know what a solar flare or convection layer is.

Wrong answers:
b) I don't think the question is absurd.

Redaction: Jeffery, 2001jan01

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008 qmult 00450 2 1 3 moderate memory: solar granule
11. A granule is:

a) a kind of cereal.
b) a grain of dust.
c) the top of a rising current of **HOT** gas in the Sun. Granules are seen in the solar photosphere. They last about 10 minutes and then lose their identity with their surroundings. The risen gas **COOLS** and then sinks.
d) the top of a rising current of **COLD** gas in the Sun. Granules are seen in the solar photosphere. They last about 10 minutes and then lose their identity with their surroundings. The risen gas **HEATS** up and then sinks.
e) a solar flare by another name.

SUGGESTED ANSWER: (c)

If one remembers that granules are in the Sun then two answers are ruled out.
Cox-364 confirms that the mean lifetime of granules is 10 minutes.

Wrong answers:
d) Rising matter in convection is hot.
e) A rather stupid synonym if it were true.

Redaction: Jeffery, 2001jan01

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008 qmult 00510 1 4 3 easy deducto-memory: five Sun outer layers 1
12. The five outermost layers of the Sun (defining layers of the Sun generously) can be labeled:

a) convection zone, photon, chromosome, coronation street, and solar sail.
b) convection zone, photosphere, chromosphere, corona, and solar sail.
c) convection zone, photosphere, chromosphere, corona, and solar wind.
d) convection zone, photon, chromosome, corona, and glabron.
e) construction zone, photosphere, chromosphere, corona, and glabron.

SUGGESTED ANSWER: (c)

Wrong answers:
a) You've got to be kidding.
b) Not solar sail.
d) A glabron is a nonce word meaning hairless particle. Just in case you needed to know.

e) Construction zones are on Earth, cowboy.

Redaction: Jeffery, 2001jan01

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008 qmult 00514 1 4 1 easy deducto-memory: two of five Sun outer layers 3

13. Two of the five outermost layers of the Sun (defining layers of the Sun generously) are:

a) photosphere and chromosphere. b) carnation and corona. c) corona and paloma. d) rio and sands. e) chromosphere and Asteroid Belt.

SUGGESTED ANSWER: (a)

Wrong answers:
d) Rio and sands? This is the Las Vegas answer.

Redaction: Jeffery, 2001jan01

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008 qmult 00710 1 1 4 easy memory: corona visible to naked eye

14. The corona of the Sun is only visible to the naked eye:

a) at sunset. b) when the Moon is a crescent in the western sky. c) during partial solar eclipses. d) during total solar eclipses. e) when the Sun is below the horizon.

SUGGESTED ANSWER: (d)

Wrong answers:
c) Well no.

Redaction: Jeffery, 2001jan01

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008 qmult 00750 2 3 3 moderate math: corona extent and Mercury

15. The solar corona has no sharp boundary, but it has been traced out to about 30 solar radii. The Sun's equatorial radius is 6.96342×10^8 m and the astronomical unit in meters is $1.49597870700 \times 10^{11}$ m. How far has the corona been traced out in astronomical units and does this trace of the corona reach to the orbit of Mercury which has a mean radius of 0.38709893 AU?

a) 0.387 AU and yes. b) 0.14 AU and yes. c) 0.14 AU and no. d) 0.387 AU and no. e) 1 AU and yes/no.

SUGGESTED ANSWER: (c)

Se-151 gives $30\,R_\odot$ as the record for tracing the corona. See Cox-12 for the Sun's radius and the astronomical unit and Cox-294 for Mercury's orbital radius.

Behold:

$$\begin{aligned} R_{\text{corona}} &\approx 30\,R_\odot \\ &\approx 30\,R_\odot \times \left(\frac{6.96342 \times 10^8\,\text{m}}{R_\odot}\right)\left(\frac{1\,\text{AU}}{1.49597870700 \times 10^{11}\,\text{m}}\right) \\ &\approx 0.14\,\text{AU}\ . \end{aligned}$$

So the corona according to the given radius does not reach to Mercury at 0.38709893 AU from the Sun.

Fortran Code

```
          print*
          rsun=6.95508d+8       ! Cox mean radius, equatorial radius
6.96342(65)e+8 m https://en.wikipedia.org/wiki/Sun
          au=1.49597870700d+11  ! Cox-12
https://en.wikipedia.org/wiki/Astronomical_unit defined value
          rsunau=rsun/au
          rcorona=30.d0*rsunau
          print*,'rsunau,rcorona'
          print*,rsunau,rcorona
    !  4.64918382023468170E-003  0.13947551460704044
```

Wrong answers:
e) As Lurch would say: "Aaaarh."

Redaction: Jeffery, 2001jan01

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008 qmult 00800 1 4 4 easy deducto-memory: solar wind defined
16. The solar wind is:

a) the air that blows off the northern hemisphere oceans during geomagnetic storms.
b) the plasma gas that cools the Sun's photosphere.
c) an optical illusion in the corona that causes the corona to look like fluffy orange clouds.
d) the plasma gas that streams from the Sun out into **INTERSTELLAR SPACE**.
e) the plasma gas that streams from the Sun out into **INTERGALACTIC SPACE**.

SUGGESTED ANSWER: (d)

Wrong answers:
e) The solar wind doesn't make it to intergalactic space.

Redaction: Jeffery, 2001jan01

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008 qmult 00810 1 4 4 easy deducto-memory: solar wind speed
17. The solar wind is a stream of particles that moves approximately along radial paths outward from the Sun: inward is the negative direction and positive is the outward direction. The solar wind near the Earth is typically moving at a radial velocity of about:

a) $-200\,\mathrm{km/s}$. b) $-200\,\mathrm{m/s}$. c) $-200\,\mathrm{cm/s}$. d) 400 to 500 km/s. e) 400 to 500 km.

SUGGESTED ANSWER: (d)

Wrong answers:
e) Wrong units.

Redaction: Jeffery, 2001jan01

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008 qmult 00820 2 3 5 moderate math: solar wind mass loss
18. The Sun loses mass at a rate of about $2 \times 10^9\,\mathrm{kg/s}$. Convert this rate into solar masses per year to the same number of significant figures as given. **NOTE:** The mass of the Sun is $M_\odot = 1.9885 \times 10^{30}\,\mathrm{kg}$ and the length of a year in seconds to 0.5 % accuracy is $\pi \times 10^7\,\mathrm{s}$.

a) $2 \times 10^{30}\,\mathrm{kg/yr}$. b) $2 \times 10^{-30}\,M_\odot/\mathrm{yr}$. c) $2 \times 10^9\,M_\odot/\mathrm{yr}$. d) $3 \times 10^{14}\,M_\odot/\mathrm{yr}$.
e) $3 \times 10^{-14}\,M_\odot/\mathrm{yr}$.

SUGGESTED ANSWER: (e)

Behold:

$$2 \times 10^9\,\mathrm{kg/s} \approx 2 \times 10^9\,\mathrm{kg/s} \times \left(\frac{1\,M_\odot}{1.9885 \times 10^{30}\,\mathrm{kg}}\right)\left(\frac{\pi \times 10^7\,\mathrm{s}}{1\,\mathrm{yr}}\right)$$
$$\approx 3 \times 10^{-14}\,M_\odot/\mathrm{yr}$$

Foukal, P. 1990, *Solar Physics,* (New York: John Wiley & Sons, Inc.), p. 436 coughs up this much hidden number $2 \times 10^{12}\,\mathrm{g/s}$ or $3 \times 10^{-14}\,M_\odot/\mathrm{yr}$. Se-152 is wrong; FMW-293 is wrong too.

Wrong answers:
d) The Sun would be gone in a flash at this rate.

Redaction: Jeffery, 2001jan01