Astronomy 102A: 1st Exam  
2005 Feb10 Thursday

Instructions: There are 50 multiple-choice questions and the test is out of 50 marks. Choose the BEST answer, completion, etc., and darken fully the appropriate circle on the TABLE provided on page 2. Read all responses carefully. NOTE that long, detailed responses won’t depend on hidden keywords: keywords in such responses are BOLD-FACED capitalized.

This is a CLOSED-BOOK exam. NO cheat sheets allowed. Calculators are permitted. This a 75 minute exam. Remember your name (and write it down on the exam too). DO NOT discuss the test with those in any section who have not taken it.

You must show a photo id when handing in the exam.
NAME:

Answer Table for the Multiple-Choice Questions

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001 qmult 01530 3 1 4 tough memory: comet orbit eccentricities

1. Most comets that are gravitationally bound to the Sun have very elliptical orbits. This means that the eccentricity of their orbits is:

   a) exactly zero.  
   b) almost zero.  
   c) exactly 1.  
   d) much bigger than zero in some sense.  
   e) bigger than 1.

**SUGGESTED ANSWER:** (d) To rule out answers in this case one has to remember both that bound orbit eccentricities must be in the range [0, 1] and that a very elliptical orbit means a very eccentric one. Thus a large eccentricity is one that is much larger than zero in a sense, but still less than or equal to 1.

**Wrong answers:**

a) Exactly wrong.

b) Almost exactly wrong.

c) Some comets may have this eccentricity as nearly as one can ever have an exact value for a quantity that is continuous.

e) This is the hard one to remember is not defined for closed orbits.

**Redaction:** Jeffery, 2001jan01

001 qmult 01700 1 1 1 easy memory: planets move about the Sun

2. To very good approximation the planets move in:

   a) elliptical orbits with the Sun at one focus of the ellipse.

   b) circular orbits with the Sun at circle center.

   c) elliptical orbits with the Sun at the center of ellipse. (The center of the ellipse is where the major and minor axes cross.)

   d) planar orbits with the Sun at plane center.

   e) spherical orbits with the Sun at sphere center.

**SUGGESTED ANSWER:** (a)

**Wrong answers:**

b) To fair approximation the planets do move in circular orbits with the Sun at circle center. Perhaps, one could even say to good approximation, not very good approximation I’d say. Anyway answer (a) is better.

d) Planar orbits? Well I suppose in the sense that elliptical orbits are confined to a plane. But does a plane have a center?

e) What are spherical orbits?

**Redaction:** Jeffery, 2001jan01

001 qmult 01720 2 1 2 moderate memory: speed on orbit

3. A planet is orbiting the Sun in an **ELLIPtical** orbit.

   a) It moves fastest at **APHELION** and slowest at **PERIHELion**.

   b) It moves fastest at **PERIHELion** and slowest at **APHELION**.

   c) It moves fastest at **HELLION** and slowest at **ANTIHELLion**.

   d) It moves at a constant speed.
e) It doesn’t move at all.

**SUGGESTED ANSWER:** (b)

**Wrong answers:**

a) Exactly wrong.

d) If the orbit were circular, this would be true.

e) As Lurch would say: “Aaarrgh.”

**Redaction:** Jeffery, 2001Jan01

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002 qmult 00210 1 1 1 easy memory: daytime define

4. Daytime is

a) the time between sunrise and sunset.  b) the time between sunset and sunrise.  c) any time of the day or night.  d) high noon.  e) an optical illusion.

**SUGGESTED ANSWER:** (a)

**Wrong answers:**

d) C’mon.

**Redaction:** Jeffery, 2001Jan01

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002 qmult 00310 2 4 2 moderate deducto-memory: parallax of astro-bodies

5. “Let’s play *Jeopardy!* For $100, the answer is: This condition of astro-bodies means that they show no parallax to unaided-eye observations for any movements about the Earth’s surface.”

What is their ____________, Alex?

a) closeness relative to the size of the Earth  b) remoteness relative to the size of the Earth  c) spherical nature  d) reflectivity  e) sensitivity

**SUGGESTED ANSWER:** (b)

**Wrong answers:**

a) Exactly wrong.

**Redaction:** Jeffery, 2001Jan01

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002 qmult 00810 1 4 3 easy deducto-memory: celestial poles

6. “Let’s play *Jeopardy!* For $100, the answer is: They are the extensions of the Earth’s axis out to the celestial sphere.”

What are ____________, Alex?

a) zenith and nadir  b) horizon and nadir  c) the north and south celestial poles (NCP and SCP)  d) the celestial equator and the ecliptic  e) the ecliptic pole and the celestial axis

**SUGGESTED ANSWER:** (c)
Wrong answers:
e) Well the NCP and SCP together constitute the celestial axis, ecliptic pole is wrong.

Redaction: Jeffery, 2001jan01

002 qmult 01000 2 4 5 moderate deducto-memory: right ascension
7. What is right ascension?
   a) The point directly below.
   b) The point directly above.
   c) The angular position of an object measured north or south from the celestial equator.
   d) The angular position of an object measured east or west from the celestial equator.
   e) The azimuthal angular position of an object measured east from the vernal (or spring) equinox.

SUGGESTED ANSWER: (e)

Wrong answers:
   a) This is nadir.
   b) This is zenith.
   c) This declination. See Skilling p. 55–57.
   d) Not from the celestial equator.

Redaction: Jeffery, 2001jan01

002 qmult 01110 2 1 2 moderate memory: zenith and nadir
8. What is zenith? What is nadir?
   a) The point directly to the east; the point directly below.
   b) The point directly above; the point directly below.
   c) A kind of television; a kind of refrigerator.
   d) The point directly above; the point directly west.
   e) The name of the spring equinox point; the name of the fall equinox point.

SUGGESTED ANSWER: (b)

Wrong answers:
   c) This is not the best meaning for zenith in the context of astronomy. I've never heard of Nadir Refrigerators. Sounds as good as Nauseous Lotion.

Redaction: Jeffery, 2001jan01

002 qmult 02300 1 1 4 easy memory: Polaris at zenith
9. Polaris is at zenith. You are:
   a) on the equator.  b) in New York City.  c) in Las Vegas.  d) near the north pole.  e) below the horizon.

SUGGESTED ANSWER: (d)
Wrong answers:
  a) Polaris would be on the horizon.
  b) Oh c’mon, you know you’re not.
  c) Have you ever seen it at Zenith in Las Vegas?
  e) Well relative to someone else I suppose.

Redaction: Jeffery, 2001jan01

002 qmult 02800 1 4 3 easy deducto-memory: Sun motion
10. Every day the Sun moves west in the sky. Relative to the fixed stars it is:
   a) not moving. b) moving mainly west. c) moving mainly east.
   d) moving mainly north. e) oblique.

SUGGESTED ANSWER: (c)

Wrong answers:
  a) It does move relative to the fixed stars. That is why the night time stars
     change with the season.
  d) A nonsense answer.

Redaction: Jeffery, 2001jan01

002 qmult 03010 1 4 4 easy deducto-memory: summer solstice
11. When the Sun is at the (northern hemisphere) summer solstice, it is:
   a) at the most southern point (i.e., most southern declination) of the ecliptic from
      the celestial equator.
   b) on the celestial equator.
   c) in the Big Dipper asterism.
   d) at the most northern point (i.e., most northern declination) of the ecliptic from
      the celestial equator.
   e) at zenith.

SUGGESTED ANSWER: (d)

Wrong answers:
  a) The Sun is high in the northern sky then, not low.
  b) Only at the equinoxes is the Sun on the equator.
  c) The Big Dipper is far from the Zodiac. The Sun is never there.
  e) the Sun can only be at zenith in the tropics.

Redaction: Jeffery, 2001jan01

002 qmult 03100 3 4 2 tough deducto-memory: gnomon shadow
12. Say you are in the northern hemisphere and have a gnomon (a stick set in the ground
    and set perpendicular to the ground). It is the winter solstice and noon. It is sunny
    and clear.

   a) The shadow of the gnomon points due SOUTH.
b) The gnomon has its shortest shadow for that day, but it has its **LONGEST** noon shadow of the year.

c) The gnomon shadow points due **EAST** and it is the longest it can be for that day.

d) The gnomon has no shadow.

e) The gnomon has its shortest shadow for that day and it has its **SHORTEST** noon shadow of the year.

**SUGGESTED ANSWER:** (b) A lot of facts have to be put together.

**Wrong answers:**

d) Now Gnomon may not see his shadow, but he does have one.

**Redaction:** Jeffery, 2001jan01

000 qmult 00100 1 1 4 easy memory: scientific method

**Extra keywords:** physci KB-24-1 but much altered

13. The scientific method can be schematically described as:

   a) an inward spiral of theorizing and experiment/observation.   b) an integrative process.   c) a reductive process.   d) a cycle of theorizing and experiment/observation.   e) a pointless pursuit.

**SUGGESTED ANSWER:** (d)

**Wrong answers:**

b) Say what?

c) Say what?

e) As Lurch would say: “Aaaaarh.”

**Redaction:** Jeffery, 2001jan01

000 qmult 00200 1 4 3 easy deducto-memory: physics defined

**Extra keywords:** physci

14. Physics can be briefly defined as the science of:

   a) human relations.   b) sports and leisure.   c) matter and motion.   d) matter and rest.   e) light.

**SUGGESTED ANSWER:** (c)

**Wrong answers:**

b) As Lurch would say: “Aaaarh.”

e) Light is only part of physics. Matter and motion is more descriptive, but not totally descriptive.

**Redaction:** Jeffery, 2001jan01

000 qmult 00350 2 4 1 moderate deducto memory: genetic algorithm

15. Evolution by survival of the fittest is used in computer calculations to find optimum solutions to problems where the solutions are treated as breeding entities. The best known of such techniques is called the:
a) genetic algorithm method.  b) scientific method.  c) method.  d) no-name method.  e) son of the method.

**SUGGESTED ANSWER:** (a)

**Wrong answers:**

- c) This is what Marilyn Monroe and Marlon Brando used.
- e) As Lurch would say: “Aaaarh.”

**Redaction:** Jeffery, 2001jan01

004 qmult 00020 1 1 5 easy deducto-memory: neolithic astronomy

16. Moon-shaped cut marks on bones in groupings of order 30 from neolithic times (as long ago as 36,000 BCE) suggest that people then were doing astronomy by:

   a) whiling away the time.  b) counting sheep.  c) witlling.  d) counting fingers and toes.  e) counting days of the lunar month.

**SUGGESTED ANSWER:** (e) See No-xxiv and Cox-16.

**Wrong answers:**

- a) As Lurch would say: “Aaaarh.”

**Redaction:** Jeffery, 2001jan01

004 qmult 03010 1 4 4 easy deducto-memory: Earth/heaven physics

17. “Let’s play *Jeopardy!* For $100, the answer is: This person’s work made astronomy in a sense and to a degree an experimental science in that he/she showed that the same physics applies on Earth and in the heavens.”

   Who is ____________, Alex?

   - a) Ben Franklin (1706–1790)
   - b) Caroline Herschel (1750–1848)
   - c) Johann Sebastian Bach (1685–1750)
   - d) Isaac Newton (1642/3–1727)
   - e) Galileo Galilei (1564–1642)

**SUGGESTED ANSWER:** (d)

**Wrong answers:**

- a) Old Ben was great scientist, but mathematical astronomy was not his forte.
- e) He tried to go there, but didn’t really make it.

**Redaction:** Jeffery, 2001jan01

001 qmult 00120 1 1 2 easy memory: megaparsec

18. A megaparsec (Mpc) is a unit typically used for:

   - a) interstellar distances.
   - b) intergalactic distances.
   - c) terrestrial distances.
   - d) foot races.
   - e) horse races.

**SUGGESTED ANSWER:** (b)

**Wrong answers:**
a) Parsecs are used in this case.
e) Furlongs are used here: a furlong is an eighth of a mile or 220 yards.

**Redaction:** Jeffery, 2001Jan01

001 qmult 00220 1 3 3 easy math: length of year in seconds
19. The length of a Julian year of 365.25 days in seconds is:
   
a) 60 s.  
b) 86400 s.  
c) about $\pi \times 10^7$ s.  
d) about $10^6$ s.  
e) about $2.2 \times 10^6$ s.

**SUGGESTED ANSWER:** (c) It is just a coincidence, but the length of a year is $\pi \times 10^7$ s to within 0.5%.

**Fortran Code**

```fortran
print*  
xjyr=365.25  
daysec=86400.  
yearsec=xjyr*daysec  
pi=acos(-1.)  
print*,’yearsec,yearsec*1.e-7/pi’  
print*,yearsec,yearsec*1.e-7/pi  
* 3.15576E+07 1.00451
```

**Wrong answers:**

b) This is the length of a day.

d) This is the rounded-off to 1 significant figure length of a day.

**Redaction:** Jeffery, 2001Jan01

001 qmult 00300 1 1 1 easy memory: astronomical unit
20. The mean distance from the Earth to the Sun in astronomical units (AU) is:

   a) 1 AU.  
b) 40 AU.  
c) $1.496 \times 10^{13}$ cm.  
d) 1.5 AU.  
e) 8 arcminutes.

**SUGGESTED ANSWER:** (a) Super-easy memory question.

**Wrong answers:**

   c) This not in AU.

**Redaction:** Jeffery, 2001Jan01

001 qmult 00600 1 3 2 easy math: Earth speed on equator
21. The Earth rotates once a day and has an equatorial radius of 6378 km. What is the speed of a point on the equator relative to a system orbiting with the Earth, but not rotating?

   a) 1 km/s.  
b) 0.46 km/s.  
c) $3 \times 10^5$ km/s.  
d) 1 km.  
e) 0.46 km.

**SUGGESTED ANSWER:** (b) In this question we can ignore the small difference between solar and sidereal day. It makes most sense to use the sidereal
day, but that day is a bit less than the 24 hour standard solar day. In fact the standard solar day is actually a bit less than the true mean solar day. The solar day is slowly increasing in time and the standard solar day was chosen to agree with the true mean solar day of about 1900.

Fortran Code

```fortran
print*
pi=acos(-1.)
radearth=6.378136e+6  ! Cox-340
daysec=86400.
daysid=.99726968
veq=2.*pi*radearth/daysec ! This is, of course relative to Sun.
print*,’The synodic equatorial speed is ’,veq ! 463.831 m/s
veq=2.*pi*radearth/(daysec*daysid) ! This is relative to fixed stars
print*,’The sidereal equatorial speed is ’,veq ! 465.101 m/s
acf=veq**2/radearth
print*,’The equatorial centrifugal force per mass is ’,acf ! 3.39157E-02
```

Wrong answers:

- c) This is the speed of light.
- d) Wrong units.
- e) Wrong units.

Redaction: Jeffery, 2001jan01

001 qmult 00620 2 5 4 moderate thinking: falling speed in 3 seconds

22. The acceleration due to gravity of a free-falling object on the surface of the Earth is \( g = 9.8 \text{ m/s}^2 \). If an object falls from rest and one can neglect air resistance, what is its speed after 3 seconds?

- a) 9.8 m/s².
- b) 9.8 m/s.
- c) 0.1 m/s.
- d) about 30 m/s.
- e) 98 m/s.

SUGGESTED ANSWER: (d) A rate times a time gives the amount. In this case

\[ v = gt = 9.8 \text{ m/s}^2 \times 3 \text{ s} = 29.4 \approx 30 \text{ m/s} . \]

Wrong answers:

- a) Wrong units.

Redaction: Jeffery, 2001jan01

001 qmult 00900 1 4 3 easy deducto-memory: Pluto-Sun distance

23. Pluto’s mean distance from the Sun is about:

- a) 1 AU.
- b) 0.1 AU.
- c) 40 AU.
- d) 1 light-year.
- e) 1.2 AU.
SUGGESTED ANSWER: (c) Students will probably not remember the value. They must deduce the right answer. More exactly Pluto’s mean distance from the Sun is 39.44 AU.

Wrong answers:
 a) This is the Earth-Sun distance.
 b) This is less than the Earth-Sun distance and Pluto is an outer planet.
 d) Light-years are interstellar distances.
 e) 1.2 should seem way too close to Earth.

Redaction: Jeffery, 2001jan01

001 qmult 01300 1 1 4 easy memory: degree, arcminute, arcsecond
24. How many degrees in a circle, arcminutes in a degree, and arcseconds in an arcminute?

a) 100, 10, 10. b) 360, 10, 10. c) 360, 100, 100. d) 360, 60, 60.
 e) 360, 24, 60.

SUGGESTED ANSWER: (d) Those ancient Mesopotamians used a sexagesimal system for astronomy although not consistently. Probably, they didn’t like complex division and choose a base of 60 because it has 12 whole number factors. This ancient sexagesimal system is also why hours have 60 minutes and minutes have 60 seconds.

Wrong answers:
 a) All things are wrong.

Redaction: Jeffery, 2001jan01

001 qmult 01330 2 4 4 moderate deducto-memory: star angular separation
25. Two stars are a fist width’s apart on the sky. (The fist is at arm’s length.) What is the angular separation of the two stars? How far apart are they in space?

a) The angular separation is about 100° and the stars are separated by about 100 light-years.
b) The angular separation is about 360° and the stars are separated by about 360 light-years.
c) The angular separation is about 10° and the stars are separated by about 10 light-years.
d) The angular separation is about 10°. The spatial separation CANNOT be determined from the given information.
e) The angular separation is about 1 arcsecond. The spatial separation CANNOT be determined from the given information.

SUGGESTED ANSWER: (d) See Se-18.

Wrong answers:
 a) 100° is more than a quadrant separation. Nobody’s fist at arm’s length is that large. The spatial separation is indeterminate in this question.
b) Angular separation by 360° is 0° angular separation.
d) One arcsecond separation is really too small.

Redaction: Jeffery, 2001jan01

001 qmult 01420 1 4 2 easy deducto-memory: inverse-square function
26. A curve on a plot that decreases as 1 over the square of the horizontal axis coordinate represents a/an _______ function.
   a) linear          b) inverse-square  c) quadratic  d) logarithmic  
   e) perpendicular

SUGGESTED ANSWER: (b)

Wrong answers:
   e) As Lurch would say: “Aaaarh.”

Redaction: Jeffery, 2001jan01

001 qmult 01422 2 5 4 moderate thinking: infinity at zero
27. If a function goes to infinity at the zero of the horizontal coordinate axis (often called the x axis), it
   a) is a linear function.  b) may be a linear function.  c) must be an inverse-square function.  d) may be an inverse-square function.  e) cannot be an inverse-square function.

SUGGESTED ANSWER: (d)

Wrong answers:
   e) As Lurch would say: “Aaaarh.”

Redaction: Jeffery, 2001jan01

001 qmult 01432 2 1 1 moderate memory: base 10 log scale
28. On a base 10 logarithmic scale, the unit is a factor of:
   a) 10.  b) e.  c) 2.512.  d) 3.  e) 2.

SUGGESTED ANSWER: (a)

Wrong answers:
   b) This is true of a natural logarithm scale.
   c) This is true of a astronomical magnitude scale.

Redaction: Jeffery, 2001jan01

003 qmult 00400 1 4 5 easy deducto-memory: Moon phase sunrise
29. At sunrise you see the Moon in the eastern sky. It is:
   a) partially eclipsed.  b) a waxing crescent.  c) a full moon.  d) a gibbous moon.  e) a waning crescent.

SUGGESTED ANSWER: (e)
Wrong answers:
a) As Lurch would say: “Aaaaah.”

Redaction: Jeffery, 2001Jan01

003 qmult 00420 2 4 5 moderate deducto-memory: full Moon opposition
30. The Sun is setting; the Moon is 180\degree away from the Sun on the sky. The Moon is:
   a) setting too.   b) half-full.   c) a crescent.   d) being eclipsed.
   e) rising and it is full.

SUGGESTED ANSWER: (e)

Wrong answers:
d) It could be eclipsed, but it “aint necessarily so.”

Redaction: Jeffery, 2001Jan01

003 qmult 00600 1 4 2 easy deducto-memory: Moon phase horned
31. The Moon is a crescent—the horned Moon. Which way, in a rough sense, do the horns point relative to the Sun?
   a) Toward the Sun.   b) Away from the Sun.   c) They can have any orientation depending on the time of year.
   d) They can have any orientation depending on the time of day.   e) Perpendicular to the line from the Moon to the Sun.

SUGGESTED ANSWER: (b) The illuminated face of the Moon always points toward the Sun. Therefore the bow of the crescent must be toward the Sun and the horns away.

Wrong answers:
a) This would look really weird.

Redaction: Jeffery, 2001Jan01

003 qmult 00702 1 4 2 easy deducto-memory: sidereal period
32. “Let’s play Jeopardy! For $100, the answer is: A lunar time period that is 27.32166 days long.”

What is the __________, Alex?
   a) lunar month   b) lunar sidereal period   c) lunar anomalistic month
   d) lunar draconitic month   e) lunar pathetic month

SUGGESTED ANSWER: (b) See Cox-16 for the various lunar time periods.

Wrong answers:
c) The anomalistic month is the time from perigee to perigee: mean value 27.55455 days (Cox-16).
   d) The draconitic month is time from a node to the same node: mean value 27.21222 days (Cox-16).
e) I just made this up.

Redaction: Jeffery, 2001jan01

003 qmult 00900 1 3 2 easy math: lunar angular speed sidereal
33. The mean lunar sidereal period is 27.322 days. The angular velocity of the moon relative to the fixed stars is:

\[ \begin{align*}
a) & \text{12.19° per day.} \\
b) & \text{13.18° per day.} \\
c) & \text{27.32° per day.} \\
d) & \text{360° per day.} \\
e) & \text{13.18°.}
\end{align*} \]

SUGGESTED ANSWER: (b) This could be done by straight memory, but it is intended to be a calculational problem. The student must realize that a complete sidereal period takes the Moon through 360° relative to the fixed stars. Then \( \frac{360°}{27.322 \text{ days}} = 13.18° \) per day.

Wrong answers:
\[ \begin{align*}
a) & \text{This is the angular velocity relative to the Sun.} \\
c) & \text{This number looks suspiciously over-familiar.} \\
d) & \text{This number looks suspiciously fast.} \\
e) & \text{This has wrong units.}
\end{align*} \]

Redaction: Jeffery, 2001jan01

003 qmult 01200 1 4 5 easy deducto-memory: Earth focus of ellipse
34. The Earth is at:

\[ \begin{align*}
a) & \text{the geometrical center of the Moon’s ELLIPTICAL orbit.} \\
b) & \text{the geometrical center of the Moon’s ECLIPTICAL orbit.} \\
c) & \text{both foci (i.e., focuses) of the Moon’s elliptical orbit.} \\
d) & \text{the perigee of the Moon’s orbit.} \\
e) & \text{one of the foci (i.e., focuses) of the Moon’s elliptical orbit.}
\end{align*} \]

SUGGESTED ANSWER: (e) Two isolated gravitationally bound bodies orbit in ellipses with their mutual center of mass at one of the foci of the ellipses. If one body is much more massive than the other, it is effectively at the center of mass. In the Earth-Moon system, the Earth is very much the dominant mass, and the Earth’s center is nearly at the center of mass relatively speaking. So it makes sense in many cases to say the Moon orbits the Earth with the Earth at one focus of the elliptical orbit. But if one is dealing with the Earth’s tides, one does have take into consideration the Earth’s orbiting the center of mass.

Wrong answers:
\[ \begin{align*}
a) & \text{A geometrical center is not a focus.} \\
b) & \text{Elliptical, not eclipitical. The similarity of these two words is sometimes confusing, but their meanings are distinct.} \\
c) & \text{The Earth is not in two places at once.} \\
d) & \text{The Earth is never at the perigee of the Moon’s orbit; the Moon, however, is there once per orbit.}
\end{align*} \]
Redaction: Jeffery, 2001jan01

003 qmult 01300 2 4 1 moderate deducto-memory: Moon ecliptic angle
35. The plane of the Moon’s orbit is:

a) at an inclination of about 5° from the ecliptic plane.
b) at an inclination of about 5° from the ecliptic pole.
c) at an inclination of about 50° from the ecliptic plane.
d) in the ecliptic plane.
e) parallel to, but far above, the ecliptic plane.

SUGGESTED ANSWER: (a) This can be answered as straight fact question. But the answer can also be deducted.

Wrong answers:
b) This would make the Moon’s orbit and the ecliptic nearly perpendicular which is from casual observation very unlikely.
c) Again unlikely from casual observation.
d) If this were so, we would have solar and lunar eclipses monthly.
e) We would never have eclipses.

Redaction: Jeffery, 2001jan01

003 qmult 01400 1 4 4 easy deducto-memory: lunar eclipse
36. A lunar eclipse can occur only when the Moon is:

a) a crescent.    b) half full.    c) gibbous.    d) full.    e) waning gibbous.

SUGGESTED ANSWER: (d) The Moon can’t be in the Earth’s shadow unless it’s opposite the Sun: i.e., it’s full.

Wrong answers:

b) When half full the Moon is at a right angle to the Sun as seen from Earth.

Redaction: Jeffery, 2001jan01

003 qmult 01600 2 4 5 moderate deducto-memory: Earth penumbra
37. From the penumbra of the Earth, the:

a) Sun cannot be seen at all.    b) Moon cannot be seen at all.    c) stars cannot be seen.    d) planets cannot be seen.    e) Sun is partially visible.

SUGGESTED ANSWER: (e)

Wrong answers:
d) As Lurch would say: “Aaaarh.”

Redaction: Jeffery, 2001jan01

003 qmult 01700 1 4 4 easy deducto-memory: lunar eclipse seen
38. Given clear skies everywhere, from what part of the Earth is a lunar eclipse visible?
a) From almost the entire day side.  

b) From a small region near the equator. 

c) From half of the night side.  

d) From almost the entire night side.  

e) It is not visible at all.

**SUGGESTED ANSWER:** (d) The eclipsed Moon is a full Moon and so opposite the Sun, in fact nearly exactly opposite given that it is eclipsed. Thus it can be seen from the dark side. An object infinitely far from the Earth and opposite the Sun could be seen by anyone on the night side in the idealized case. Even those on the day-night border could see it on their horizon. Well the Moon is rather far from the Earth, but not effectively infinitely far. So there may be marginal regions close to the day-night border where it can’t be seen. But practically it should be visible from most of the night side.

**Wrong answers:**

e) Surely not.

**Redaction:** Jeffery, 2001jan01

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003 qmult 01800 2 4 3 moderate deducto-memory: lunar eclipse coppery

39. When totally eclipsed, the Moon often appears reddish or coppery. Why?

a) Reddish is the Moon’s natural color. When the glaring white light of the Sun is removed, we see this natural color.

b) Some sunlight is **REFLECTED** from the Earth’s atmosphere and re-directed toward the Moon. Light reflected by the atmosphere tends to be reddish. Thus the atmosphere reflected light gives the Moon its reddish color. The direct white light from the Sun completely (or almost completely) washes out any reddish color when the Moon is not totally eclipsed.

c) Some sunlight is **REFRACTED** from the Earth’s atmosphere and toward the Moon. (Refraction bends light beams toward the normal to the media interface when the medium the light is entering has a higher index of refraction. In the case of the Earth’s atmosphere, refraction tends to bend the light beams around the Earth.) The atmosphere preferentially scatters blue light (hence the blue of the day-time sky) and transfers red light (hence the red color of the Sun at sunrise and sunset when more of the blue has been scattered out of the line of sight). Thus, the refracted light is reddish. This reddish light is reflected by the Moon, and hence we see the Moon as reddish. The direct white light from the Sun completely (or almost completely) washes out any reddish color when the Moon is not totally eclipsed.

d) The reddish color is an optical illusion caused by the human eye’s tendency to see as red that which is not green.

e) The Moon is actually red hot: i.e., it is emitting red light due to high surface temperature. The eclipsed face of the Moon is after all the day side of the Moon, and we all know about day-time temperatures on the Moon. The direct white light from the Sun completely (or almost completely) washes out any reddish color when the Moon is not totally eclipsed.

**SUGGESTED ANSWER:** (c) A moderate memory question. One just has to remember it is refraction of sun light in the Earth’s atmosphere which causes the
Wrong answers:
   a) Actually a reflecting object’s color is determined by its intrinsice properties and the spectrum of the light that is shining on it. Thus objects don’t really have natural color. Of course, given that the light is always white light (which is basically what humans like to use usually) objects will have definite colors. Under white light, the Moon is sort of grey?? I think. The contrast with the dark sky makes it look white or even silvery at least in story and song: “by the li-i-i-ght of the silvery Mo-o-o-o-on, I want to cro-o-o-o-n ...”
   b) Refracted not reflected.
   d) I just made this up: unless I’ve made a lucky hit, it’s total nonsense.
   e) The day side of the Moon is hot (up to 130°C; see Se-445), but not red hot.
      Red hot is, well, hotter: like a glowing burner—however hot that is.

Redaction: Jeffery, 2001Jan01

003 qmult 02100 2 5 1 moderate thinking: solar eclipse seasons
40. For eclipses (any of partial, total, annular, or penumbral) to occur, the nodes do not have to be exactly on the Earth-Sun line: i.e., the line drawn through the centers of Earth and Sun. This is because the light-emitting body, the eclipsing body, and the eclipsed body all have finite size. The eclipse season is the period during which nodes are sufficiently close to an alignment that an eclipse is possible. The eclipse season for the Sun (total, annular, and partial) is about 34 days: 17 days before exact alignent and 17 days after. Will there be solar eclipse of some kind in every solar eclipse season?

   a) Solar eclipses can only happen at nearly exact NEW MOON. If the Moon is just past an eclipsing NEWISH MOON when a solar eclipse season begins, the Sun misses an eclipse just at the start of the season. The Moon will get back to new moon in a lunar month of about 29.5 days. This is less than the eclipse season, and thus a solar eclipse will occur. Clearly if the Moon enters the solar eclipse season at any other phase, a solar eclipse MUST HAPPEN as well.
   b) Solar eclipses can only happen at nearly exact FULL MOON. If the Moon is just past an eclipsing FULLISH MOON when a solar eclipse season begins, the Sun misses an eclipse just at the start of the season. The Moon will get back to new moon in a lunar month of about 29.5 days. This is less than the eclipse season, and thus a solar eclipse will occur. Clearly if the Moon enters the solar eclipse season at any other phase, a solar eclipse MUST HAPPEN as well.
   c) Solar eclipses can only happen at nearly exact NEW MOON. If the Moon is just past an eclipsing NEWISH MOON when a solar eclipse season begins, the Sun misses an eclipse just at the start of the season. The Moon will get back to new moon in a lunar month of about 29.5 days. This is less than the eclipse season, and thus a solar eclipse will occur. Clearly if the Moon enters the solar eclipse season at any other phase, a solar eclipse will NOT occur.
   d) Solar eclipses can only happen at nearly exact FULL MOON. If the Moon is just past eclipsing FULLISH MOON when a solar eclipse season begins, the Sun misses an eclipse just at the start of the season. The Moon will get back to new moon in a lunar month of about 29.5 days. This is less than the eclipse
season, and thus a solar eclipse will occur. Clearly if the Moon enters the solar eclipse season at any other phase, a solar eclipse will NOT occur.
e) The Bos Domesticus effect in which the Sun sort of dodges the Moon happens frequently near nodal alignment. This often prevents solar eclipses.

**SUGGESTED ANSWER:** (a) This is moderate thinking question (type 03). I get my eclipse season periods from Se-47 whom I trust more than Motz and Duveen p. 128 oddly enough. I done my own calculation and my values are a bit smaller than Motz and Duveen and closer to Seeds. I think one can see the reasoning from the question and right answer themselves.

**Wrong answers:**

b) The Moon has to be in front of the Earth not behind it for a solar eclipse. Thus solar eclipses happen at new moon, not full moon.
c) Reason it out. There must be a solar eclipse.
d) Full moon again. Must be a solar eclipse again.
e) High diddle, diddle, the cat and a fiddle, the ... According to the Oxford English Dictionary, the domestic cow is is Bos Taurus, but Bos Domesticus sounds better.

**Redaction:** Jeffery, 2001jan01

003 qmult 02300 3 4 2 tough deducto-memory: Sun corona defined 1 41. The solar corona:

a) is a thin surface layer of the Sun seen as a thin pink ring surrounding the totally eclipsed Sun. The corona often has eruptions of gas called solar prominences.
b) is the outermost part of the atmosphere of the Sun. It is a very hot, rarefied gas. Although very hot (of order 10^6 K), the corona is very **Faint** because of it’s low density. In **TOTAL SOLAR ECLIPSES** it becomes visible to the unaided human eye. It has a milky white color and appears rather wispy. Magnetic field lines extending out from the Sun tend to concentrate corona gas into filaments.
c) is the outermost part of the atmosphere of the Sun. It is a very hot, rarefied gas. Although very hot (of order 10^6 K), the corona is very **Bright** because of it’s low density. In **TOTAL SOLAR ECLIPSES** it becomes visible to the unaided human eye. It has a milky white color and appears rather wispy. Magnetic field lines extending out from the Sun tend to concentrate corona gas into filaments.
d) is the outermost part of the atmosphere of the Sun. It is a very hot, rarefied gas. Although very hot (of order 10^6 K), the corona is very **Faint** because of it’s low density. In **TOTAL AND ANNULAR SOLAR ECLIPSES** it becomes visible to the unaided human eye. It has a milky white color and appears rather wispy. Magnetic field lines extending out from the Sun tend to concentrate corona gas into filaments.
e) was a **CROWN** awarded to the preeminent astronomer of ancient Greece. Poets have their laurel wreath; astronomers have their crown. Demosthenes (384?–322 BCE), defying tyranny, argued in his oration **On the Crown** that it should not be given to Alexander (356–323 BCE) for discovering that the Sun at sunrise in India is not a hundred times larger than in Greece. Later Ptolemy (circa 100–175 CE) was awarded the crown.
SUGGESTED ANSWER: (b)

Wrong answers:
a) That’s the chromosphere: see Se-45.
c) Low density in gas tends to faintness, not brightness in gas emission. This can be understood by imagining density going to zero.
d) Annular eclipses are apparently too bright to allow the corona to be seen by eye.
e) Drivel. Some ancient person made an oration On the Crown I think but it wasn’t about astronomy. Maybe it was Cicero. Of course, Alexander and his mates did find out that the Sun at sunrise was the same size in Greece and in India. But the Greek philosophers had assumed that for a long time. There were probably earlier reports too. Ptolemy is sometimes shown wearing a crown in Medieval pictures (see Se-59), but this was because Medievals thought he had to belong to the Ptolemaic dynasty—you know, Cleopatra, etc.

Redaction: Jeffery, 2001jan01

003 qmult 02400 1 4 4 easy deducto-memory: visible corona
42. Why is the corona visible to the unaided eye only during a total solar eclipse?

- a) It is behind the photosphere of the Sun ordinarily, and thus cannot be seen ordinarily.
- b) The Moon’s shadow usually hides it.
- c) Only during total eclipses is it compacted by magnetic fields.
- d) It is too faint to be seen when any significant part of the photosphere of the Sun is visible.
- e) Only a total solar eclipse is long enough to let it stand out.

SUGGESTED ANSWER: (d)

Wrong answers:
- a) Nah, it surrounds the Sun of which of course it is the outermost layer.
- b) It’s not in the Moon’s shadow. It’s far away from the Moon’s shadow and much bigger too.
- c) The magnetic fields of the Sun aren’t affected by eclipses.
- e) The corona is there all the time. If time alone was enough to see it, we would always see it.

Redaction: Jeffery, 2001jan01

005 qmult 00100 1 5 5 easy thinking: victory of Newtonian heliocentrism
43. The contest in the 16th and 17th centuries in Europe between the geocentric and heliocentric world models was won by the heliocentric world model. The victory was a modified one. Heliocentrism no longer meant, as it did for Copernicus and Kepler, the Sun at the center of the universe, but only the Sun at the center of the planetary system of the Sun. The universe was generally taken to be much larger, perhaps infinite, and the stars recognized as perhaps other suns. The basis of the victory was that planetary and terrestrial motions were derived mathematically
and with high accuracy from a small set of very abstract axioms (i.e., postulated
physical laws) and initial conditions. The derived planetary motions conformed to
the heliocentric view in that the Sun caused the planets to move as they did whereas
the planets barely affected the motion of the Sun. From a geometrical point of view
the Sun could be described as moving around the Earth or the Earth, around the Sun.
This had long been recognized: e.g., probably by Ptolemy (circa 100–175 CE). The
contested issue had not been geometrical description, but physical causation. The
goecentric world model had been basically the Aristotelian one either in pure form
(e.g., Aristotle's own system which was not even altogether qualitatively accurate) or
in the Ptolemaic or Ptolemaic-like forms (which were or could be made quantitatively
accurate). The Aristotelian world model had been based on Aristotelian physics. By
modern standards Aristotelian physics is very unsatisfactory: it is almost entirely
qualitative and is not always even qualitatively accurate and it is rather ad hoc (i.e.,
new principles need to be invented to explain new phenomena). One strength of
Aristotelian physics was that in many instances it agreed with the common sense,
concrete sense of the world: e.g., “the Earth's at rest or we'd feel it moving”; “a
hammer falls faster than a feather.” That Aristotelian physics and cosmology had
been brought into concordance with Medieval theology was another strength in a
time in which it was thought by many that the world should and did manifest the
divine in an easily accessible manner. The theological concordance seemed to offer
a guarantee of absolute truth, whereas the axiomatic, mathematical physics, only a
provisional truth. The victory of the new physics and the new heliocentric system of
the world showed that quantitative accuracy and mathematical elegance had come to
be valued above naive common sense and naive concrete sense and that the religious
objections could in fact be overcome. The victory was effectively completed by:

Newton (1642/3–1727).

SUGGESTED ANSWER: (e) An easy thinking question after the long
harangue.

Wrong answers:
 a) Aristotle was the patron of the old physics and system.
 b) He started the contest, he didn’t end it.
 c) Galileo obviously didn’t triumph and he wasn’t the completer of the victory—
 he was a great intermediate figure.
 d) Kepler wasn’t able to convince most of the world of heliocentric system and
didn’t invent much anyway of the new physics.
 e) Newton was born 1642dec25 on the Julian calendar used in England all of
this life. This 1643jan04 on the modern Gregorian calendar that was used
in most of the rest of Europe at that time.

Redaction: Jeffery, 2001jan01

005 qmult 00200 1 1 4 easy memory: hammer and feather on Moon
44. Drop a feather and hammer at the same time on the Earth and then on the Moon.
a) They both hit the ground at the same time on both worlds.
b) The hammer lands first by a large margin on both worlds.
c) The feather lands first on both worlds.
d) The feather lands second on Earth and at about the same time as the hammer on the Moon.
e) The feather lands second on Earth and first by a large margin on the Moon.

**SUGGESTED ANSWER:** (d)

**Wrong answers:**
  a) The air resistance on Earth slows down the feather.
  b) On the Moon, the air resistance is negligible.

**Redaction:** Jeffery, 2001jan01

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005 qmult 00400 1 1 3 easy memory: Newton’s 1st law 1
45. Newton’s first law states:

a) a body continues at rest or in ACCELERATED motion in a straight line in an inertial frame unless acted on by a net force.

b) a body continues at rest or in DECELERATED motion in a straight line in an inertial frame unless acted on by a net force.

c) a body continues at rest or in UNIFORM (constant speed) motion in a straight line in an inertial frame unless acted on by a net force.

d) a body is ALWAYS at rest in an inertial frame unless acted on by a net force.

e) a body is always at rest in an inertial frame unless acted on by GRAVITY.

**SUGGESTED ANSWER:** (c) The right answer is also the longest answer.

**Wrong answers:**
  b) Deceleration is usually defined as an acceleration that points opposite to the direction of velocity.

**Redaction:** Jeffery, 2001jan01

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005 qmult 00500 1 1 5 easy memory: Newton’s 3rd law
46. Newton’s 3rd law states:

a) for every force, there is an EQUAL and PERPENDICULAR force.

b) for every force, there is an SMALLER and PERPENDICULAR force.

c) for every force, there is an EQUAL and OPPOSITE force. The two forces act on the same body always, and so their are no accelerations at all.

d) for every force, there is a LARGER and OPPOSITE force.

e) for every force, there is an EQUAL and OPPOSITE force.

**SUGGESTED ANSWER:** (e)

**Wrong answers:**
  c) Accelerations do happen.

**Redaction:** Jeffery, 2001jan01
005 qmult 00550 1 5 3 easy thinking: inertial frames

47. Inertial frames are:

   a) rotating frames.
   b) accelerating frames.
   c) frames in which Newton’s laws of motion ARE obeyed. They are all UNACCELERATED with respect to each other.
   d) frames in which Newton’s laws of motion ARE obeyed. They are all ACCELERATED with respect to each other.
   e) frames in which Newton’s laws of motion ARE NOT obeyed. They are all UNACCELERATED with respect to each other.

**SUGGESTED ANSWER:** (c)

**Wrong answers:**

   d) From somewhere I recall Newton did once think about having 6 laws of motion, but decided to settle on 3.

**Redaction:** Jeffery, 2001jan01

005 qmult 00570 3 1 3 tough thinking: rotating frame

48. A rotating frame (i.e., rotating with respect to an inertial frame) is:

   a) NOT an inertial frame. Nevertheless, there CAN BE NO accelerations in such a frame without a force.
   b) an inertial frame.
   c) NOT an inertial frame. There CAN BE accelerations in such a frame without a force.
   d) BOTH an exact inertial frame and an exact non-inertial frame at the same time.
   e) a practical impossibility.

**SUGGESTED ANSWER:** (c) A tough memory question on a test, but not so tough on a homework.

**Wrong answers:**

   e) So much for all those years spend on playground merry-go-rounds.

**Redaction:** Jeffery, 2001jan01

005 qmult 00580 2 5 3 moderate thinking: Newton’s laws not obvious

49. Newton’s laws of motion are:

   a) obvious. This is why Aristotle knew them more than 23 centuries ago. He just rejected them for moral reasons.
   b) not obvious. Nevertheless, Aristotle knew of the them more than 23 centuries ago. He just rejected them for hygienic reasons.
   c) not obvious. To get to them, one probably first has to imagine what happens in the absence of all resistive media.
   d) 6 in number.
e) not obvious. To get to them, one probably first has to imagine what happens in the center of the Earth.

**SUGGESTED ANSWER:** (c) This is really a thinking question, if the Professor has not spoken ex cathedra.

**Wrong answers:**

a) If Newton’s laws were obvious, why did they take so long to be discovered and why don’t students just know them.

b) Aristotle: not likely.

d) There are only 3.

e) The center of the Earth is a red herring.

**Redaction:** Jeffery, 2001jan01

005 qmult 00600 114 easy memory: force definition

50. A force is:

a) what sustains a constant velocity.

b) what sustains a uniform motion.

c) the same as acceleration.

d) a physical relation between bodies or between a body and a the field of some force that causes a body to accelerate (if not balanced by other forces).

e) a physical relation between bodies that causes them to orbit each other.

**SUGGESTED ANSWER:** (d)

**Wrong answers:**

e) This only happens in some cases. But it’s not a general statement of what a force is.

**Redaction:** Jeffery, 2001jan01