**Introductory Astronomy** **NAME:**

**Homework 14: Mars:** 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:

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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!

2. Going outward from the Sun, Mars is the:

   a) 4th planet. b) 3rd planet. c) 10th planet. d) 1st planet. e) 3rd and 5th planet.

3. The planet Mars gets its name from:

   a) a candy bar. b) Cinq-Mars, a close friend of Louis XIII. c) the Greek god of peace. d) the Roman god of war. e) Santa's chief elf.

4. Mars was discovered in:

   a) 1610 by Galileo Galilei (1564–1642). b) 1655 by Christiaan Huygens (1629–1695). c) 1869 by Pietro Angelo Secchi (1818–1878). d) 1877 by Giovanni Schiaparelli (1835–1910). e) in prehistory by numerous persons no doubt.

5. The Martian canals:

   a) were first widely introduced (but not first "discovered") by Giovanni Schiaparelli (1835–1910) in **1877** as explanations for features he saw on Mars. His Italian word *canale* (which does not necessarily imply artificial water channel in Italian) was misleadingly translated as canal in English. Percival Lowell (1855–1916) picked up the idea of canals and believed that they proved intelligent life on Mars. He mapped out the canals in detail using his Lowell Observatory in Flagstaff, Arizona. With the probable exception of Valles Marineris, all his canals were apparently illusions: one supposes artifacts of the eye trying to see shapes in unresolvable or barely resolvable markings.
   b) were first widely introduced (but not first "discovered") by Giovanni Schiaparelli (1835–1910) in **1877** as explanations for features he saw on Mars. His Italian word *canale* (which does not necessarily imply artificial water channel in Italian) was misleadingly translated as canal in English. Percival Lowell in **1980** picked up the idea of canals and believed that they proved intelligent life on Mars. He mapped out the canals in detail using his Lowell Observatory in Flagstaff, Arizona. Despite the recent NASA probes to Mars showing no canals, Lowell still maintains the canals are really there. Supermarket tabloids thoroughly support him and ascribe NASA's contrary findings to government cover-up.
   c) were first widely introduced (but not first "discovered") by H.G. Wells (1866–1946) in **1898** in his book *The War of the Worlds*. In that book they were the handiwork of intelligent Martian octopuses: evolution had made the Martians all brain and fingers. Wells's natural son Orson Welles (1915–1985) (who had Americanized his surname) based his Mars invasion Halloween radio show of 1938, *The War of the Worlds,* on his father's book. The radio show caused considerable panic (especially in New Jersey) among people who were perhaps predisposed by various 20th century events to believe in remorseless, faceless invaders. In any case, in his later years Welles revealed that the canals had always been a hoax.
   d) are now dry, but once they carried water from the polar caps to Valles Marineris which was then a long narrow sea. Although the canals are almost certainly natural, the idea that extinct Martians built them to supply water to their cities (Martian versions of Las Vegas) is still held by some noted scientists such a Percival Lowell, Orson Welles, and Liberace.
   e) include the Suez, Panama, and Welland Canals.

6. Mars has seasons principally because:

   a) it is red. b) its axis is tilted by about $25°$ to the pole perpendicular to Mars's orbital plane. c) its orbit is super-highly elliptical. d) of its volcanoes. e) of its impact craters.

7. The Mars's diameter in units of Earth's diameter is about:

   a) 10. b) 5. c) 1. d) 1/2. e) 1/1000.

8. Briefly describe the seasonal color variations of one hemisphere of Mars' surface. (The basic color of Martian soil is reddish probably due to high iron oxide [rust] content).

   a) In the spring, increasing warmth causes green **PLANT LIFE** to flourish and this plant life covers much of the red soil surface. Hence a hemisphere surface becomes greener in spring. In the fall, the plant life declines and the hemisphere surface becomes redder again.

b) In the spring, increasing warmth causes **PLANT LIFE** to change from red to green, greening the appearance of the surface of a hemisphere. In the fall, the plant life turns red again, reddening the appearance of the surface.
c) In the spring a hemisphere's white polar cap, which extends to the **EQUATOR** in winter, retreats leaving a red soil surface. In the fall, white polar cap grows back to the equator turning the hemisphere white again.
d) Dust storms cover some of the Martian surface with **GREEN DUST**. In the spring, apparently the winds strip away some of the dust leaving a **REDDER** soil surface. Thus a hemisphere appears greener in the winter and redder in the summer.
e) Dust storms tend to cover Martian surfaces with **RED DUST**. In the spring, apparently the winds strip away some of the dust. Some of the underlying surface is dark rather than red, and so the surface becomes darker in appearance when the dust is blown away. The darker surface appears greenish in comparison to the overall red of the Martian surface. Thus a hemisphere appears redder in the winter and greener in the summer.

9. On Mars:

a) Valles Marineris is an alluvial plain, Olympus Mons is a dry ocean, Syrtis Major is a large canal, and Hellas Planitia is a large impact basin.
b) Valles Marineris is a smile, Olympus Mons is a wart, Syrtis Major is a *Star Trek* character, and Hellas Planitia is a plantation.
c) Valles Marineris is a large canyon, Olympus Mons is a large volcano, Syrtis Major is a large dark region, and Hellas Planitia is a large impact basin.
d) Valles Marineris is a large volcano, Olympus Mons is a large canyon, Syrtis Major is a large impact basin, and Hellas Planitia is a large dark region.
e) Valles Marineris is a large impact basin, Olympus Mons is a large dark region, Syrtis Major is a large canyon, and Hellas Planitia is a large volcano.

10. Valles Marineris is a:

a) Hibernian bog.
b) small valley on Venus.
c) small valley on Mars that was probably formed by a huge river, now of course completely dry.
d) large valley on Mars that was probably formed by the Martian crust cracking and subsiding somehow.
e) large valley on Mars that was probably formed by a long drought early in Martian history.

11. The Martian polar ice caps are:

a) possibly permanent **CARBON DIOXIDE** ice covered in winter by a layer of **WATER** ice. In the spring, the water ice layer **MELTS** and the water quickly evaporates. The carbon dioxide ice remains through the summer. Remember, at a given pressure, carbon dioxide ice **MELTS** at a higher temperature than water ice. In the fall, water vapor condenses on the polar caps again.
b) possibly permanent **WATER** ice covered in winter by a layer of **CARBON DIOXIDE** ice. In the spring, some or all of the carbon dioxide (all at the northern cap it seems) **SUBLIMES** (i.e., passes directly to gas phase): the atmospheric pressure on Mars is too low to for a liquid carbon dioxide phase to exist. In the fall, carbon dioxide condenses on the polar caps again.
c) possibly permanent **CARBON DIOXIDE** ice covered in winter by a layer of **WATER** ice. In the spring, the water ice **SUBLIMES** (i.e., passes directly to gas phase): the atmospheric pressure on Mars is too low to for a liquid water phase to exist. Remember, at a given pressure, carbon dioxide ice **SUBLIMES** at a higher temperature than water ice. In the fall, water vapor condenses on the polar caps again.
d) made of whitish rock.
e) ordinary water snow. They melt totally in the spring and then are reconstituted by large snow storms in the late fall and winter.

12. Circa 2003, analysis of dendritic channels on Mars based on Mars Global Surveyor data led to the conclusion that in some cases at least these channels were very probably:

a) glacial melt ponds. b) glacial melt oceans. c) rain-fed run-off channels. d) rain-fed canals. e) snow-fed canals.

13. "Let's play *Jeopardy*! For $100, the answer is: The discovery in 2003 of this feature on Mars proves that at some time in the past there was continuous liquid water flow on Mars."

    What is a ____________, Alex?

    a) glacier b) tidal shoal c) gully d) river delta or distributary fan (which is closely related to, but not the same thing as, a river delta) e) rotary fan (which was likely a river delta)

14. Why is it thought that there was once flowing liquid water on Mars?

    a) The water ice at the **POLAR CAPS** suggests this.
    b) The two kinds of dry channels found on Mars. The first kind are runoff-like channels which are meandering and dendritic (branchy), and are thought to have been rain-fed rivers. They are found in the old Martian highland and are perhaps older than 3.9 billion years. They are tens of meters in width and perhaps 10 to 20 km long. The second kind are the **MARTIAN CANALS** which also suggest that there was once intelligent life of on Mars.
    c) The two kinds of dry channels found on Mars. The first kind are runoff-like channels which are meandering and dendritic (branchy), and are thought to have been rain-fed rivers. They are found in the old Martian highland and are perhaps older than 3.9 billion years. They are tens of meters in width and perhaps 10 to 20 km long. The second kind are the circular channels that are concentric around large impact craters. There are usually between 3 and 7 of these circular channels. It is hypothesized that they were constructed by the **MARTIANS** in order to make dart board patterns.
    d) The two kinds of dry channels found on Mars. The first kind are runoff-like channels which are meandering and dendritic (branchy), and are thought to have been rain-fed rivers. They are found in the old Martian highland and are perhaps older than 3.9 billion years. They are tens of meters in width and perhaps 10 to 20 km long. The second kind are are called **OUTFLOW CHANNELS OR ARROYOS**. The largest are 10 km or more in width and hundreds of kilometers long. It is hypothesized that these outflow channels were produced **TECTONIC PLATES** grinding against each other. The liquid water in outflow channels was an inconsequential and inconspicuous later incident.
    e) The three kinds of dry channels found on Mars. The first kind are runoff-like channels which are meandering and dendritic (branchy), and are thought to have been rain-fed rivers. They are found in the old Martian highland and are perhaps older than 3.9 billion years. They are tens of meters in width and perhaps 10 to 20 km long. The second kind are are called **OUTFLOW CHANNELS OR ARROYOS**. These are 10 km or more in width and hundreds of kilometers long. It is hypothesized that these outflow channels were produced by **SUDDEN, LARGE FLOODS**. The floods occurred when an impact or volcano suddenly melted a large amount of frozen water in the soil (i.e., permafrost). The **THIRD KIND** are river delta formations. These formations are considered absolute proof that there was continuous water flow on Mars at some time in its history.

15. "Let's play *Jeopardy*! For $100, the answer is: NASA researchers in 1996 proposed that this object possibly contained fossilized Martian microbes."

    What is ____________, Alex?

    a) Pathfinder b) Viking 1 c) Beagle 2 d) star Cary Grant 1904
    e) meteorite Allan Hills 84001

16. Why is life as we know it not possible (without some extreme adaptions) on the surface of present-day Mars?

    a) The surface of Mars is relatively **UNPROTECTED** from sterilizing UV radiation because of its thin atmosphere which in particular has no UV-absorbing ozone layer. But there is, however, **PLENTY** of liquid water (which is necessary for life) in the deep bottoms craters where the atmospheric pressure is high.
    b) First, the surface of Mars is relatively **UNPROTECTED** from sterilizing UV radiation because of its thin atmosphere which in particular has no UV-absorbing ozone layer. Second, liquid water (which is necessary for life as we know it) **CANNOT** exist for long on the Martian surface due to the low atmospheric pressure.
    c) First, the surface of Mars is relatively **PROTECTED** from sterilizing UV radiation because of its thin atmosphere which in particular has no UV-absorbing ozone layer. Second, liquid water

(which is necessary for life as we know it) **CANNOT** exist on the Martian surface due to the low atmospheric pressure.

d) First, the surface of Mars is relatively **PROTECTED** from sterilizing UV radiation because of its thin atmosphere which in particular has no UV-absorbing ozone layer. But there is, however, **PLENTY** of liquid water in the deep bottoms craters where the atmospheric pressure is high.

e) We've never found any life, so there isn't any.

17. Life (as we know it) on Mars' surface appears impossible. It is speculated that subsurface life may exist. Why?

a) The Viking and Pathfinder probes detected abundant traces of **ORGANIC MOLECULES** when they drilled **SEVERAL HUNDREDS** of meters below the surface. Organic molecules are necessary for life, but are not sufficient evidence of it.

b) Below the surface the temperature is much **LOWER** and conditions much **DRYER,** and this would allow life to exist.

c) Below the surface there may be **SUFFICIENT WARMTH** from the Mars interior to sustain life. (Mars probably still has significant though it is insufficient for very obvious geological activity.) The heat and higher subsurface pressure could allow liquid water to exist (in rock pores), and liquid water is also needed for life. Additionally, below the surface, life would be protected from ultraviolet radiation. The **LACK** of any deep crustal life (i.e., life deeper than a few meters) on Earth, however, makes the idea of subsurface life on Mars very speculative.

d) Below the surface there may be **SUFFICIENT WARMTH** from the Mars interior to sustain life. (Mars probably still has significant though it is insufficient for very obvious geological activity.) The heat and higher subsurface pressure could allow liquid water to exist (in rock pores, etc.), and liquid water is also needed for life. Additionally, below the surface, life would be protected from ultraviolet radiation. The **PRESENCE** of deep crustal life (i.e., life to down to perhaps a few kilometers: i.e., a deep biosphere) on Earth lends credence to the idea of subsurface Martian life. In fact, some people now wonder if subsurface life may the commonest form of life in the Universe.

e) The exo-biology people will grasp at any straw.

18. Why are Mars's moons Phobos and Deimos so nonspherical?

a) Excessive cratering constantly stops the "spherizing" effect of gravity.

b) Volcanic effects continually distort their shapes.

c) Their mass is small, and thus their self-gravity is insufficient to force them to be spherical by overcoming the structural electromagnetic forces of their material and, perhaps, their centrifugal force due to their rotation.

d) Their mass is small, and thus their self-gravity is insufficient to force them to be spherical against the effect of the solar wind.

e) The tidal force of Mars has pulled them into football shapes.

19. Mars's moons Phobos and Deimos are small, nonspherical bodies with triaxial dimensions in kilometers of about $27 \times 21.6 \times 18.8$ and $15 \times 12.2 \times 11$, respectively. Their mean distances from Mars center are 2.761 and 6.906 Mars radii (1.470 and 3.678 Earth radii). Their eccentricities are 0.015 and 0.0005. Their orbital periods and rotational periods are the same length: the periods for Phobos are 0.31891023 days and for Deimos are 1.2624407 days. They both orbit eastward. Because Phobos' orbital period is shorter than Mars' rotational period (1.02595675 days), Phobos rises west and sets east. Deimos rises east and sets west, but moves relatively slowly across the sky relative to a local sky coordinate system. The moons are probably captured asteroids. The exact sameness (on average) of moons's orbital and rotational periods shows that they are tidally locked to Mars. Why would this be expected?

a) Because of the strength of the solar wind.

b) They are close to Mars, and so Mars's tidal force is probably quite **STRONG**. Moreover, their small size meant that they probably had **INCREDIBLY HUGE ROTATIONAL KINETIC ENERGY** when they started orbiting Mars. The **MORE** the initial rotational kinetic energy, the easier it was to get rid of enough of it to have slowed them down to the tidally locked situation. Thus their probably huge initial rotational kinetic energy also helped tidal locking to occur.

c) They are close to Mars, and so Mars's tidal force is probably quite **STRONG**. Moreover, their small size meant that they probably had **LOW ROTATIONAL KINETIC ENERGY** when they started orbiting Mars, unless they were rotating incredibly quickly. The **LOWER** the initial rotational kinetic energy (provided it was greater than needed for tidally locking), the easier it was to get rid of enough of it to have slowed them down to the tidally locked situation. If they had insufficient initial rotational kinetic energy for tidal locking, the Martian tidal force would have had to speed them up: but since they are small bodies, that added amount of rotational kinetic energy was probably relatively small. Thus because of their small size, it was probably relatively easy to change their rotational kinetic energy to just the amount needed for tidal locking.

d) They are close to Mars, and so Mars's tidal force is probably quite **WEAK**. Moreover, their small size meant that they probably had **INCREDIBLY HUGE ROTATIONAL KINETIC ENERGY** when they started orbiting Mars. The **MORE** the initial rotational kinetic energy, the easier it was to get rid of enough of it to have slowed them down to the tidally locked situation. Thus their probably huge initial rotational kinetic energy also helped tidal locking to occur.

e) They are close to Mars, and so Mars's tidal force is probably quite **WEAK**. Moreover, their small size meant that they probably had **LOW ROTATIONAL KINETIC ENERGY** when they started orbiting Mars, unless they were rotating incredibly quickly. The **LOWER** the initial rotational kinetic energy (provided it was greater than needed for tidally locking), the easier it was to get rid of enough of it to have slowed them down to the tidally locked situation. If they had insufficient initial rotational kinetic energy for tidal locking, the Martian tidal force would have had to speed them up: but since they are small bodies, that added amount of rotational kinetic energy was probably relatively small. Thus because of their small size, it was probably relatively easy to change their rotational kinetic energy to just the amount needed for tidal locking.