Physics 90 Final Exam

May 18, 2020

*You may use the OpenStax textbook and your class notes, **including all materials for all of the five units**, by going here:* https://observatree.github.io/physics90

and then scrolling down to the detailed schedule links. You can use a calculator. You can't use Google or your friends. During the official final exam time, 8:00-10:00am, I will be waiting on Zoom (usual meeting code, https://stmarys-ca.zoom.us/j/866254786*). If you think you found a typo, or if a question is badly worded, join the Zoom session and ask me about it. **When done**, submit a one-page (or more if necessary) Word, PDF, or plain text document **with just your answers** using Moodle TurnItIn.*

If you have SDS permission for extended time or any other unusual consideration, like your calculator batteries were dead (I'm just making an example up), or you have to take care of something unusual due to shelter-in-place, you may use more than the standard 8:00-10:00am time period, but please complete the exam expeditiously.

Coordinate Systems

1. Latitude

The latitude of the south pole is:

(A) +180°
(B) +90°
(C) 0°
(D) -90°

2. Declination

The declination of Orion's Belt is about:

(A) +180°
(B) +90°
(C) 0°
(D)-90°

HINT: Three of these you can rule out easily! So it must be the remaining one.

3. Right Ascension

Right ascension is measured with a sidereal clock which is set to 0h when ______________ passes across the observing slit.The blank is:

(A) Polaris the North Star
(B) Orion the Hunter
(C) The First Point of Aries
(D) Cygnus the Swan

4. Right Ascension

If you look through a slit in the roof and something with Right Ascension 6h goes across it, and you keep still and looking through the slit whatever comes into view after three more hours has right ascension of about:

(A) 3h
(B) 6h
(C) 9h
(D) 12h

Apparent Magnitude (or just “Magnitude”)

In the modern magnitude system, Vega has magnitude 0. If the brightness of star 1 is B_1 and the brightness of star 2 is B_2, and the magnitudes are m_1 and m_2, then

$$\frac{B_1}{B_2} = 100^{(m_2 - m_1)/5}$$

Also, since $100^{1/5}$ is about 2.5, we sometimes approximate and say each step (e.g., 1 → 2 or 15 → 16) is a factor of 2.5 dimmer.

5. Apparent Magnitude

In the modern magnitude system, two steps less (e.g., 4→2) would be about:

(A) 5 times brighter
(B) 6.3 times brighter
(C) 16 times brighter
(D) 100 times brighter

6. Apparent Magnitude

Sirius has magnitude -1.46. This is __________ than a magnitude 0 star by a factor of ___________. The blanks are:

(A) brighter — $100^{1.46}$.
(B) brighter — $100^{1.46/5}$.
(C) dimmer — $100^{1.46}$.
(D) dimmer — $100^{1.46/5}$.

Wave, Wave Speed, Period and Frequency

The definition for frequency in terms of period is

$$f \equiv \frac{1}{P}$$

The main formula for waves of light is

$c = \frac{\lambda}{P}$ where the speed of light $c = 3\,\text{x}10^{8}\text{m/s}$

From this and the definition of frequency, you can also get $c = \lambda f$.

7. Frequency and Period

What period corresponds to 1 GHz?

(A) 10^{9} seconds
(B) 10^{6} seconds
(C) 10^{-6} seconds
(D) 10^{-9} seconds

8. Frequency from Wavelength

In the last unit we learned about the cosmic microwave radiation. It is about 1mm in wavelength. The corresponding frequency is:

(A) $3\,\text{x}10^{11}$Hz
(B) $3\,\text{x}10^{9}$Hz
(C) $3\,\text{x}10^{9}$Hz
(D) $3\,\text{x}10^{9}$Hz (OOPS, I meant to change B, C, and D to have different, wrong, answers)

Temperature, Color, and Blackbody Radiation

The two main formulas for the various temperature scales, which you can rearrange to get lots of others are:

$T_{\text{Celsius}} = T_{\text{Kelvin}} - 273$

and

$T_{\text{Fahrenheit}} = \frac{9}{5} T_{\text{Celsius}} + 32$

For an object that is radiating electromagnetic waves the radiated light has a peak in the spectrum, and the location for the peak is:

$\lambda_{\text{peak}} = \frac{2.9\,x\,10^6\text{ nm Kelvin}}{T}$ (you might find it convenient to round 2.9 to 3)

9. The Kelvin scale

Water boils at 100°C. So on the Kelvin scale, water boils at:

(A) 0K
(B) 273K
(C) 373K
(D) 5777K

10. Temperature Scales

The temperature of the surface of our Sun is 5777 K. Convert to Celsius, and then convert to Fahrenheit. The temperature of the surface of our Sun in Fahrenheit is about:

(A) 1,000 °F
(B) 10,000 °F
(C) 100,000 °F
(D) 1,000,000 °F

11. Temperature and Wavelength

For the 3K cosmic microwave background radiation, the peak wavelength is about:

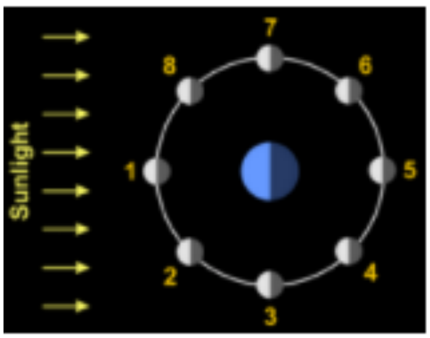
(A) 10^6 nm (which is $10^3\mu$m or 1mm) (B) 10^3 nm (C) 1nm (D) 10^{-3} nm

12. Temperature and Color

If a star produces about equal amounts of all three primary colors — blue, green and red — all three kinds of cones in your eye would be excited equally, and the star would appear:

(A) brown
(B) white
(C) black

Moon Phases and Eclipses



In the diagram, you are looking down on the Earth's North pole *and the Moon is going around the Earth counterclockwise*.

13. Moon's Phases

The phase numbered 1 is:

(A) New Moon
(B) Waxing Crescent
(C) First Quarter
(D) Waxing Gibbous
(E) Full Moon

14. Moon's Phases

The phase numbered 5 is:

(A) Full Moon
(B) Waning Gibbous
(C) Third Quarter
(D) Waning Crescent
(E) New Moon

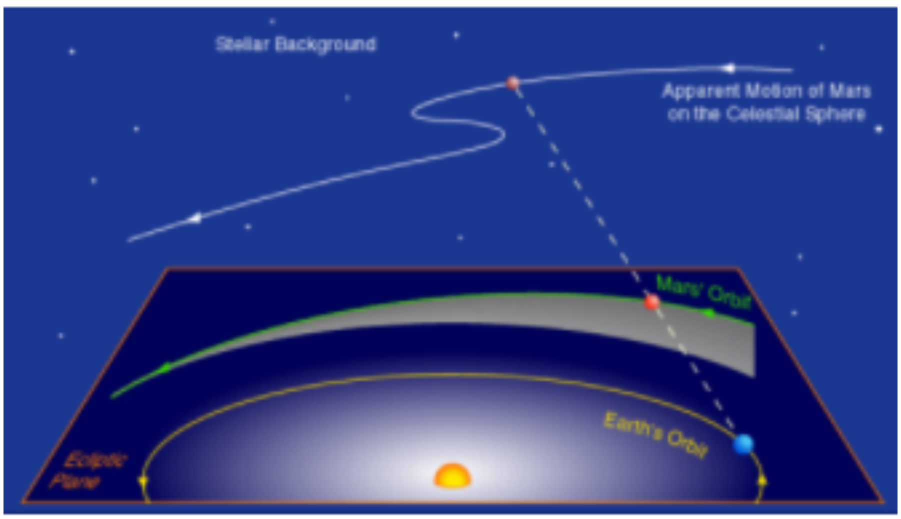
15. Moon’s Phases

Standing looking south, and looking high up at a 1st Quarter Moon just after sunset, like you did in the Galileo lab,

(A) The bright side is on the **right**, and the bright side is facing **West** where the Sun went down.
(B) The bright side was on the **left**, and the bright side is facing **West** where the Sun went down.
(C) The bright side was on the **right**, and the bright side is facing **East** where the Sun went down.
(D) The bright side was on the **left**, and the bright side is facing **East** where the Sun went down.

Prograde and Retrograde Motion

Mars has an apparent path through the stars. Below is the modern (Copernican) explanation of this:



Consult this diagram for the next problem.

16. Prograde and Retrograde Motion

A little later than shown in the picture, Mars will appear to be going “to the right” through the stars (if you are in the northern hemisphere, looking south). The usual terminology for this motion is:

(A) **prograde** motion, and Mars will be going **eastward** through the stars.
(B) **retrograde** motion, and Mars will be going **westward** through the stars.
(C) **prograde** motion, and in modern astronomy we know this is due to epicycles.
(D) **retrograde** motion, and it is actually due to epicycles.

Scale Model of the Solar System

17. Black Rock Desert Model

In Wylie Overstreet's Model in Black Rock Desert at 1:850,000,000 scale, the Sun was the side of a large beach ball. In his model, the Earth's diameter was about the same as the diameter of a

(A) small nail head (B) grape (C) doorknob (D) dessert plate

Kepler's Laws and Newton's Laws

18. Kepler's 3rd Law

Kepler's Third Law says $P^2 = a^3$. This formula:

(A) Works if P is the orbital period in earth-years and a is the semi-major axis of the orbit in A.U.
(B) Fits the data Kepler got from Tycho Brahe.
(C) Was explained by Newton's Laws of Motion.
(D) All of the above.

19. Circular Acceleration

According to the $a = v^2/r$ formula, if Star A is orbiting the galactic center at a radius of radius 30,000 light-years, and Star B is orbiting the galactic center at the same speed, v, but twice the radius, then Star B has

(A) the same acceleration as Star A
(B) twice the acceleration of Star A
(C) half the acceleration of Star A

20. Newton's Universal Law of Gravitation, Space Station

Chris Hadfield — the astronaut who played the guitar in the "Major Tom" video — has said "there is no gravity in space." Actually, on the International Space Station (ISS) the astronauts feel weightless because:

(A) the ISS is so far from the Earth, gravity is negligible
(B) the ISS is falling in a circle around the Earth and the ISS, Chris Hadfield, and his guitar are all in free fall together
(C) the ISS's gravity balances the Earth's, so that the net gravity is zero
(D) the rules Newton developed for gravity only hold on Earth, not once you get into space

21. Newton’s Universal Law of Gravitation, Proportional Reasoning

The formula for Newton’s Universal Law of Gravitation is

$$F = \frac{G m_1 m_2}{r^2}$$

Suppose Star A and Star B are identical, except that Star A is orbiting the galactic center at 30,000 light-years and Star B is at the edge of our galaxy at 60,000 light-years. Then Star B should experience

(A) twice the force as Star A
(B) four times the force as Star A
(C) half the force of Star A
(D) one-quarter the force of Star A

Mass, Volume, Density, and the Planets

The definition of density is mass over volume: $\rho \equiv \frac{M}{V}$.

22. Mass and Density of the Planets

The rocky planets have densities approximately ______ the density of water (1000 kg/m^3).

(A) the same as (B) much less than (C) about five times (D) about 25 times

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Energy, Power, Intensity, Fission, Fusion, and the Sun

The definition of power is energy over time. $P \equiv \frac{E}{t}$.

Einstein’s most famous equation is $E = mc^2$. In this equation, c is the speed of light which is 3×10^8 m/s.

23. Intensity

SunPower is in Richmond, CA. They make solar panels that are over 20% efficient! The peak intensity of sunlight (when it is directly overhead) is 1050 W/m^2. A SunPower solar panel that is 0.5m by 1.0m could produce about:

(A) 100 Watts
(B) 200 Watts
(C) 300 Watts
(D) 1000 Watts

24. Fission and Fusion

The element that stars start fusing when they first ignite is:

(A) Hydrogen
(B) Helium (a bit ambiguous, see clarification in solution)
(C) Iron
(D) Uranium
(E) Plutonium

25. Ivy Mike Fusion Bomb and $E = mc^2$

The power of the Sun was released on the Earth when the Ivy Mike H-Bomb was exploded in 1952. It produced about 4.5×10^{16} Joules.

How much mass disappeared in this explosion? HINT: UNITS!

(A) 500g (B) 50 g (C) 5 g (D) 0.5 g

26. The Structure of the Sun

The Sun’s radiative layer is outside the core but inside the convective layer. The most similar situation to the radiative layer is:

(A) The heat coming up through a poker rod if the tip of the poker is in the fireplace.
(B) The rays of light coming off the Moon.
(C) The rising currents of water in a pot of water that is about to boil.

Parallax, A.U., Parsec, Light-Year

27. Parallax

If you solve the parallax formula for R (the distance to the object), then you get

$$R = \frac{150{,}000{,}000 \text{ km x } 57.3 \text{ x } 60 \text{ x } 60 \text{ arcseconds}}{\theta}$$

To simplify their calculations, astronomers took the whole mess, 150,000,000 km x 57.3 x 60 x 60, and made a new unit out of it that is called the parsec. This unit is about:

(A) 1/3 of an A.U. (B) 3 A.U. (C) 1/3 of a light-year (D) 1 light-year (E) 3 light-years

28. Parallax

Vega's parallax was measured in 1837 to be 0.125 arcseconds. That meant Vega was

(A) 0.125 parsecs way (B) 0.875 parsecs away (C) 8 parsecs away

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Absolute Magnitude, Classification of Stars

29. Inverse Square Law for Light

The formula for intensity (called the inverse square law for light) is:

$$I = \frac{L}{4 \pi R^2}$$

Suppose two stars have the same luminosity, *L*. Suppose Star 1 is four times as far away from Earth as Star 2. Then the intensity of Star 1 we would measure is:

(A) 16 times the intensity of Star 2
(B) 4 times the intensity of Star 2
(C) 1/4 the intensity of Star 2
(D) 1/16 the intensity of Star 2

30. Inverse Square Law for Light

Imagine moving a star from 1 parsec away from us to 10 parsecs away. After the movement, the star would appear (HINT/HELP: be careful of problem rewordings!!):

(A) 100 times brighter
(B) 10 times brighter
(C) 10 times dimmer
(D) 100 times dimmer

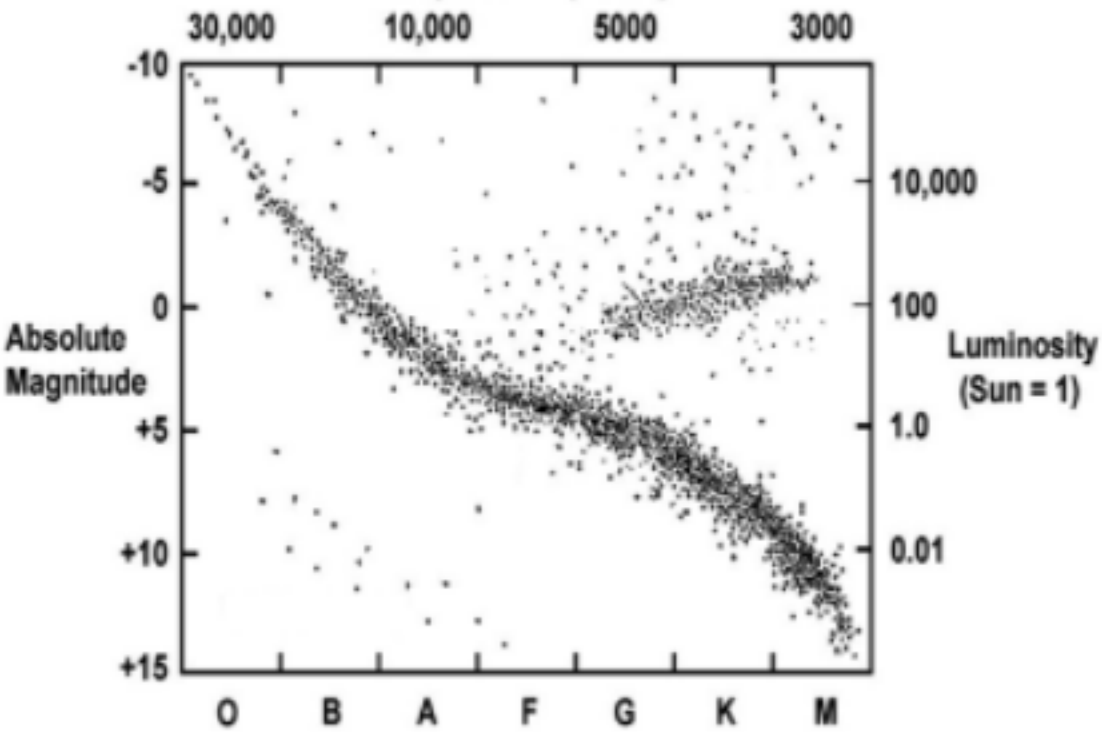
31. Absolute Magnitude

If the star in the previous problem appeared to have magnitude 2 at 1 parsec, after moving it to a distance of 10 parsecs, it would now appear to have magnitude:

(A) 3
(B) 5
(C) 7

HR Diagrams, Birth of Stars, Death of Stars, Cepheids

32. HR Diagrams



From the Hertzsprung-Russell diagram above which shows many more stars, if you see an A-Type star that is 10,000K, then most likely it has absolute magnitude:

(A) -7
(B) -2.5
(C) +2.5
(D) +7

33. HR Diagrams

Stars spend the first part of their life in the region of the HR diagram called:

(A) the main sequence
(B) the visual region
(C) the red giant region
(D) the white dwarf region

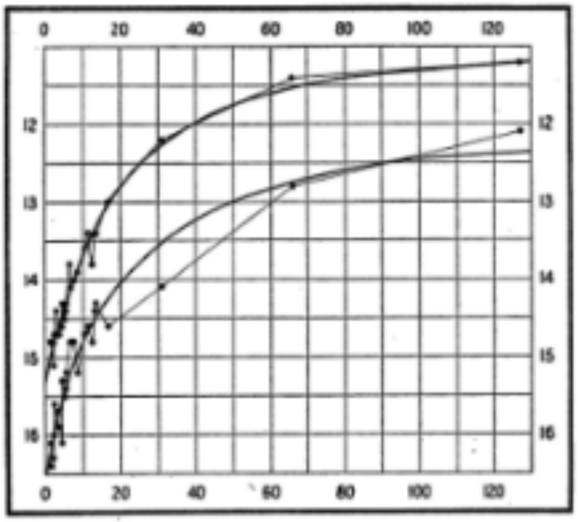


Fig. 1.

34. Period-Luminosity Relationship

In class we studied the above work by Leavitt. From her Fig. 1 above, if a star has period 90 days, then its maximum intensity is apparent magnitude:

(A) 11.3
(B) 12.5
(C) 15.5
(D) 18.0

35. Period-Luminosity Relationship

Referring to the same star as the previous problem, at its minimum intensity, its apparent magnitude is:

(A) 11.3
(B) 12.5
(C) 15.5
(D) 18.0

36. Distance from Absolute Magnitude

Suppose Leavitt saw a variable star with period 40 days. In the Small Magellanic Cloud, such a variable would have its maximum intensity with apparent magnitude 12.

If you knew that a variable with this period has at its maximum intensity absolute magnitude -7, how far away is the Small Magellanic Cloud? THIS ONE IS HARD!

(A) 6,000 parsecs
(B) 60,000 parsecs
(C) 600,000 parsecs
(D) 6,000,000 parsecs

37. Apparent Magnitude from Distance

The Andromeda Galaxy is 10 times as far away as Small Magellanic Cloud. EVEN THIS ONE IS KIND OF HARD.

Referring to the variable star in the previous problem, its apparent magnitude at maximum intensity if it were in the Andromeda Galaxy would be:

(A) 7
(B) 12
(C) 17
(D) 22

ONLY ONE PAGE TO GO!! AND AFTER THAT, ...

That's all there is
There ain't no more
Unless I see
That bear once more

(Total randomness from the "I Met a Bear" scout song.)

The Big Bang and Dark Matter

38. The Doppler Effect

Stars coming toward us have their spectra ________, stars going away have their spectra ________, and stars going perpendicularly have their spectra ___________.

(A) red-shifted / blue-shifted / unaffected
(B) blue-shifted / red-shifted / red-shifted
(C) red-shifted / blue-shifted / red-shifted
(D) blue-shifted / red-shifted / unaffected

39. The Big Bang

Hubble’s 1929 paper predicted a Big Bang. In 1964, some scientists setting up a microwave receiver observed ____________________ light from the Big Bang. This light had been traveling toward their receiver for ___________________________ of years

(A) heavily blue-shifted / thousands
(B) heavily red-shifted / thousands
(C) heavily blue-shifted / billions
(D) heavily red-shifted / billions

40. Galactic Rotation Curves

If all the mass in the galaxy were concentrated at the center of the galaxy, then for a star orbiting the center of the galaxy at radius *R* you’d expect $v = \sqrt{\frac{G\, m_{\text{Galaxy}}}{R}}$.

So you’d expect that stars closer than our Sun to the center of the galaxy would be going _________, and stars further than our Sun would be going _______, but in the real data they are all _____________________.

(A) faster / slower / going about the same speed as the Sun
(B) slower / faster / going about the same speed as the Sun
(C) faster / slower / stopped
(D) slower / faster / stopped

This is the principal evidence that our galaxy has lots of dark matter!

CONGRATULATIONS! THE END!!