

Cosmic Algebraic Constants

Algebra · Answer Key · 21 Questions

1. The Schwarzschild radius R of a non-rotating black hole is calculated as $R = 2GM/c^2$. Given G is approximately $6.674 \times 10^{-11} \text{ m}^3 \text{ kg}^{-1} \text{ s}^{-2}$ and c is 299,792,458 m/s, approximately how much does the radius change if the mass M is doubled?

- A) It remains the same
- B) It doubles**
- C) It quadruples
- D) It decreases by half

2. In Kepler's Third Law, $p^2 = a^3$, where p is the orbital period in Earth years and a is the semi-major axis in AU. If an object has a semi-major axis of 4 AU, what is its orbital period in years?

- A) 2 years
- B) 4 years
- C) 8 years**
- D) 16 years

3. The luminosity L of a star is related to its radius R and temperature T by the formula $L = 4\pi R^2 T^4$. If a star's radius is doubled and its temperature is halved, by what factor does its luminosity change?

- A) 1**
- B) 0.5
- C) 2
- D) 0.25

4. The escape velocity v of a planet is given by $v = \sqrt{2GM/r}$. If a planet's mass M is quadrupled and its radius r is doubled, what is the factor change in its escape velocity?

- A) $\sqrt{2}$**
- B) 2
- C) $\sqrt{4}$
- D) 4

5. The absolute magnitude M of a star is given by $M = m - 5(\log_{10}(d) - 1)$, where d is the distance in parsecs. If $m=5$ and $d=100$, what is the absolute magnitude M ?

- A) 0**
- B) 5
- C) 10
- D) 2

6. Hubble's Law is expressed as $v = H_0 \cdot D$. If the Hubble constant H_0 is 70 km/s/Mpc and a galaxy is 50 Mpc away, what is its recessional velocity in km/s?

- A) 350
- B) 3500**
- C) 700
- D) 7000

7. The gravitational force between two bodies is $F = G(m_1 m_2)/r^2$. If the distance r is tripled while keeping the masses constant, what is the new force as a fraction of the original?

- A) $1/3$
- B) $1/6$
- C) $1/9$**
- D) 3

8. In the equation for the Drake Equation $N = R^* \cdot f_p \cdot n_e \cdot f_l \cdot f_i \cdot f_c \cdot L$, if all variables equal 0.1 except R^* which equals 1, what is the value of N ?

- A) 0.000001
- B) 0.0001**
- C) 0.01
- D) 0.1

9. The apparent brightness b of a star follows the inverse square law $b = L / (4\pi d^2)$. If the distance d to a star is increased by a factor of 10, how does the brightness change?

- A) Decreases by $1/10$
- B) Decreases by $1/20$
- C) Decreases by $1/100$**
- D) Decreases by $1/1000$

10. The wavelength λ of a photon is related to frequency f by $c = \lambda \cdot f$. If the frequency of light is doubled, what happens to the wavelength?

- A) It is halved**
- B) It is doubled
- C) It stays the same
- D) It is squared

11. Using the formula for orbital velocity $v = \sqrt{GM/r}$, if the orbital distance r is quadrupled, how does the velocity v change?

A) It doubles

B) It halves

C) It stays the same

D) It triples

12. The Stefan-Boltzmann law states $\text{Power} = \text{Area} \cdot \sigma \cdot T^4$. If the temperature T of a black body is tripled, the power output increases by a factor of:

A) 3

B) 9

C) 27

D) 81

13. A light-year is approximately 9.46×10^{15} meters. Expressed in scientific notation, what is the result of multiplying 2 light-years by 3?

A) 5.676×10^{16}

B) 1.892×10^{16}

C) 2.838×10^{16}

D) 9.46×10^{16}

14. The density ρ of a sphere is $\rho = M / ((4/3)\pi r^3)$. If the radius r is halved while the mass M remains constant, what happens to the density?

A) It becomes 2x

B) It becomes 4x

C) It becomes 8x

D) It becomes 1/8x

15. The formula for time dilation is $t' = t / \sqrt{1 - v^2/c^2}$. As v approaches c , what happens to the value of t' ?

A) It approaches 0

B) It approaches 1

C) It approaches infinity

D) It stays constant

16. The mass-energy equivalence is $E = mc^2$. If mass is increased by 5 kg, how much does energy E increase ($c = 3 \times 10^8$ m/s)?

A) 1.5×10^{17} J

B) 4.5×10^{17} J

C) 9×10^{17} J

D) 4.5×10^{18} J

17. The angular size θ of an object is approximately $\theta = s / d$, where s is size and d is distance. If distance d doubles, what happens to θ ?

A) It doubles

B) It halves

C) It is squared

D) It is quadrupled

18. For circular orbits, the period $T = 2\pi \sqrt{r^3 / GM}$. If the mass M of the central body is increased by a factor of 4, what happens to the period T ?

A) It doubles

B) It halves

C) It stays the same

D) It becomes $1/4$

19. In the relation $Z = (\lambda_{\text{obs}} - \lambda_{\text{rest}}) / \lambda_{\text{rest}}$, if a spectral line is shifted from 500nm to 600nm, what is the redshift Z ?

A) 0.1

B) 0.2

C) 0.5

D) 1.2

20. The Drake Equation has $N = R^* f_p n_e f_l f_i f_c L$. If $R^* = 1$ and all other terms are 1, what is N ?

A) 0

B) 1

C) 10

D) 100

21. If a rocket consumes fuel at a rate dm/dt , the thrust is $F = v_e * (dm/dt)$. If both fuel consumption and exhaust velocity double, by what factor does thrust increase?

A) 2

B) 4

C) 8

D) 1