Math Subject GRE Questions

Calculus and Differential Equations

1. If $f(x) = e^x - e^{-x}$, then $[f'(x)]^2 - [f(x)]^2$ equals
   (a) 4 (b) $4e^{-2x}$ (c) $2e^{-x}$ (d) 2 (e) $2e^x$

2. An integrating factor for the ordinary differential equation $-\frac{2y}{x}\,dx + (x^2 y\cos(y) + 1)\,dy = 0$ is
   (a) 1 (b) $-\frac{2}{x}$ (c) $\frac{1}{x^2}$ (d) $-2x$ (e) x^2

3. Assuming convergence, find $x = \sqrt{3 + \sqrt{3 + \sqrt{3 + \ldots}}}$
   (a) $\frac{1}{2}(\sqrt{5}+1)$ (b) $\frac{1}{2}(\sqrt{13}-1)$ (c) $\frac{1}{2}(\sqrt{5}-1)$ (d) $\frac{1}{2}(\sqrt{13}+1)$ (e) $\frac{1}{2}(\sqrt{13}-\sqrt{5})$

4. What is the maximum perimeter of all rectangles that can be inscribed in $\frac{x^2}{a^2} + \frac{y^2}{b^2} = 1$?
   (a) $4\sqrt{a^2+b^2}$ (b) $\frac{8}{\sqrt{a^2+b^2}}$ (c) $2\sqrt{a^2+b^2}$ (d) a^2+b^2 (e) $2(a^2+b^2)$

5. Let $x_n = \frac{n^n}{n!}$ for $n = 1, 2, 3, \ldots$. Then $\lim_{n\to\infty} \frac{x_{n+1}}{x_n}$ equals
   (a) $\sqrt{e}$ (b) e (c) $\sqrt{e^3}$ (d) e^2 (e) e^{-1}

6. The derivative of $f(x) = \int_x^0 \frac{\cos(xt)}{t}\,dt$ is
   (a) $\frac{1}{x}[1 - 2\cos(x^2)]$ (b) $-\frac{\cos(2x^2)}{x}$ (c) $\frac{1}{x}[1 + 2\sin(x^2)]$ (d) $-\frac{\sin(2x^2)}{x}$ (e) $\frac{\cos(x^2)}{x}$

7. The maximum value of the directional derivative on the surface $z = f(x,y) = xe^{xy} + y\cos(x)$ at $P(0,1)$ is
   (a) 1 (b) $\sqrt{2}$ (c) $\sqrt{3}$ (d) $\sqrt{4}$ (e) $\sqrt{5}$

8. The inflection point for $f(x) = \frac{\ln(x)}{x}$ occurs at $x =$
   (a) $\sqrt{e}$ (b) e (c) $\sqrt{e^3}$ (d) e^{-1} (e) $\sqrt{e^{-1}}$

9. Given the linear second-order difference equation $y_{k+2} - y_{k+1} - 2y_k = 0$, for $k = 0, 1, 2, \ldots$ and $y_0 = 9$ and $y_1 = -12$, find y_6.
   (a) -54 (b) 64 (c) -32 (d) 27 (e) 54

10. What is the general solution of $3xy^3\,dx - (x+2)\,dy = 0$?
   (a) $3x - 4\ln(|x+2|) + \frac{1}{y^2} = c$ (b) $3x - \ln(|x+2|) + \frac{1}{3y^2} = c$
   (c) $3x - 5\ln(|x+2|) + \frac{3}{y^2} = c$ (d) $3x - 6\ln(|x+2|) + \frac{1}{2y^2} = c$

(e) $3x - 2\ln(|x+2|) + \dfrac{2}{y^2} = c$

11. The absolute maximum of $f(x) = \cos(2x) - 2\cos(x)$ on $[0, 2\pi]$ occurs at $x =$
(a) $\dfrac{\pi}{3}$ (b) $\dfrac{\pi}{2}$ (c) π (d) $\dfrac{5\pi}{3}$ (e) $\dfrac{3\pi}{4}$

12. Evaluate the sum $\displaystyle\sum_{n=1}^{m} \tan^{-1}\left(\frac{1}{n^2+n+1}\right)$
(a) m^2+1 (b) $\dfrac{1}{m^2+m}$ (c) $\cot(m+1) - \dfrac{1}{m^2+1}$ (d) $\tan^{-1}(m+1) - \dfrac{\pi}{4}$
(e) $(-1)^m \sin(m+1) + \tan(m)$

13. The smallest positive integer n for which the inequality $2^n > n^2$ is true for $\{n, n+1, \ldots\}$ is
(a) 1 (b) 2 (c) 3 (d) 4 (e) 5

14. The first Newton approximation x_1 for a zero of $f(x) = x^3 - 2x$ with initial approximation $x_0 = 2$ is
(a) $\dfrac{12}{5}$ (b) 2 (**c**) $\dfrac{8}{5}$ (d) $\dfrac{6}{5}$ (e) $\dfrac{7}{5}$

15. The value of $\displaystyle\int_1^4 |x-2|\, dx$ is
(a) 3 (b) $\dfrac{5}{2}$ (c) 2 (d) $\dfrac{3}{2}$ (e) $\dfrac{7}{2}$

16. The equation $r = 2\sin(\theta) - \cos(\theta)$ in rectangular coordinates is given by
(a) $x^2+y^2+x-2y=0$ (b) $x^2-x+2y=0$ (c) $x^2+y^2+2x-y=0$ (d) $x^2-y^2-x+2y=0$
(e) $y^2-x^2-x+2y=0$

17. The general term of the Maclaurin series for xe^{-x^2} is
(a) $\dfrac{(-1)^n x^{2n}}{(n+1)!}$ (b) $\dfrac{(-1)^{n+1} x^{2n+1}}{n!}$ (c) $\dfrac{(-1)^n x^{2n+1}}{(n+1)!}$ (d) $\dfrac{(-1)^n x^{2n+1}}{n!}$ (e) $\dfrac{(-1)^{n+1} x^{2n}}{n!}$

18. Find the value of the sum $1 + \dfrac{2}{3} + \dfrac{4}{9} + \dfrac{8}{27} + \cdots$
(a) $\dfrac{11}{3}$ (b) $\dfrac{5}{2}$ (c) 2 (d) 3 (e) ∞

19. The circles $c_1 : x^2+y^2+2ax+2by+c=0$ and $c_2 : x^2+y^2+2a'x+2b'y+c'=0$ are orthogonal if
(a) $2aa'+2bb'=c+c'$ (b) $a+a'+b+b'=cc'$ (c) $aa'-bb'=c-c'$ (d) $2aa'-2bb'=c-c'$
(e) $a+b+c=a'+b'+c'$

20. The volume (in cubic units) generated by rotating the region defined by the curves $y = x$ and $y = 2\sqrt{x}$ around the $x-$axis is
(a) $\dfrac{16\pi}{5}$ (b) $\dfrac{32\pi}{15}$ (c) $\dfrac{16\pi}{3}$ (d) $\dfrac{32\pi}{3}$ (e) π

Abstract Algebra/Topology

1. The number generators of a cyclic group of order 8 is
(a) 6 (b) 4 (c) 3 (d) 2 (e) 1

2. Find the number of solutions of the set of algebraic equations of height two.
(a) 0 (b) 1 (c) 2 (d) 3 (e) 4

3. Define a metric on $\mathbb{R}^2 = \mathbb{R} \times \mathbb{R}$ by $d[(x_1, y_1); (x_2, y_2)] = |x_2 - x_1| + |y_2 - y_1|$. The unit ball $d[(0,0); (x, y)] < 1$ is
(a) the interior of a circle with center $(0, 0)$ and radius 1.
(b) $(0, 0)$
(c) the interior of a square with vertices $(-1, 1)$, $(1, 1)$, $(1, -1)$, and $(-1, -1)$.
(d) the interior of a square with vertices $(-1, 0)$, $(0, 1)$, $(1, 0)$, and $(0, -1)$.
(e) the interior of a triangle with vertices $(-1, -1)$, $(0, \sqrt{3})$, and $(1, -1)$.

4. Which of the following is a topological property?
(a) boundedness (b) being a Cauchy sequence (c) completeness
(d) being an accumulation (limit) point (e) length

5. The number of ordered partitions of the positive integer 5 is
(a) 20 (b) 18 (c) 16 (d) 14 (e) 12

6. The conjugates of an element are the other roots of the irreducible polynomial of which the given element is a root. The conjugate of $\sqrt{\sqrt{3}+1}$ over the field of rational numbers are
(a) $\sqrt{\sqrt{3}+1}, \sqrt{\sqrt{3}-1}$ (b) $\sqrt{\sqrt{3}+1}, -\sqrt{\sqrt{3}+1}$ (c) $\pm\sqrt{1+\sqrt{3}}, \pm\sqrt{1-\sqrt{3}}$
(d) $\pm\sqrt{\sqrt{3}+1}, \pm\sqrt{\sqrt{3}-1}$ (e) $\sqrt{\sqrt{3}+1}, -\sqrt{\sqrt{3}-1}$

7. A Sylow 3-subgroup of a group of order 72 has order
(a) 3 (b) 9 (c) 18 (d) 27 (e) 36

8. Which of the following set, together with the given binary operation $*$, does not form a group?
(a) $G = \{a + b\sqrt{2} \in \mathbb{R} - \{0\} \mid a, b \in \mathbb{Q}\}$, $*$: usual multiplication of real numbers
(b) $G = \{a + bi\sqrt{2} \in \mathbb{C} - \{0\} \mid a, b \in \mathbb{Q}\}$, $*$: usual multiplication of complex numbers
(c) $G = \{\sqrt[3]{a} \in \mathbb{R} \mid a \in \mathbb{Z}\}$, $*$: for $a, b \in G$, $\sqrt[3]{a} * \sqrt[3]{b} = \sqrt[3]{a+b}$
(d) $G = \mathbb{R} - \{0\}$, $*$: for $a, b \in G$, $a * b = |a|\, b$
(e) $G = \{z \in \mathbb{C} \mid |z| = 1\}$, $*$: usual multiplication of complex numbers

9. Find the number of left cosets of the cyclic subgroup generated by $(1, 1)$ of $\mathbb{Z}_2 \times \mathbb{Z}_4$ where $\mathbb{Z}$ denotes the cyclic group of $\{0, 1, 2, \ldots, n-1\}$ under addition modulo n.
(a) 1 (b) 2 (c) 4 (d) 6 (e) 8

10. Up to isomorphism, how many Abelian groups are there of order 36?
(a) 1 (b) 4 (c) 9 (d) 12 (e) 18

11. The set of gaussian integers $R = \{a + ib \| a, b \in \mathbb{Z}\}$ is a commutative subring of the complex numbers. An element $u = e + id$ is a unit of R if there exists $v \in R$ such that $uv = 1$. The unit(s) of R is(are)
(a) ± 1 (b) $\pm i$ (c) $1, i$ (d) $\pm 1, \pm i$ (e) 1

12. The number of solutions (equivalence classes) of the congruence $3x + 11 \equiv 20 \pmod{21}$ is:
(a) no solutions (b) 1 (c) 3 (d) 4 (e) 6

13. Find the index of the subgroup generated by the permutation

$$\begin{pmatrix} 1 & 2 & 3 & 4 & 5 \\ \downarrow & \downarrow & \downarrow & \downarrow & \downarrow \\ 3 & 1 & 2 & 4 & 5 \end{pmatrix}$$

in the alternating group A_5.
(a) 20 (b) 40 (c) 24 (d) 3 (e) 5

14. Let $S = \{x_1, x_2, \ldots, x_n, \ldots\}$ be a topological space where the open sets are $U_n = \{x_1 \ldots, x_n\}$, $n = 1, 2, \ldots$. Let $E = \{x_2, x_4, \ldots, x_{2k}, \ldots\}$. Find the set of cluster points of E.
(a) $S - \{x_1, x_2\}$ (b) $\{x_1\}$ (c) $\{x_2\}$ (d) $E - \{x_2\}$ (e) $S - E$

15. A subgroup H in a group G is invariant if $gH = Hg$ for every $g \in G$. If H and K are both invariant subgroups of G, which of the following is also an invariant subgroup?
(a) $H \cap K$ (b) HK (c) $H \cup K$ (d) Both (a) and (b) (e) Both (b) and (c)

16. Let R be a ring such that $x^2 = x$ for each $x \in R$. Which of the following must be true?
(a) $x = -x$ for all $x \in R$ (b) R is commutative (c) $xy + yx = 0$ for all $x, y \in R$
(d) Both (a) and (c) (e) All of (a), (b), and (c)

17. In the integral domain $D = \{r + s\sqrt{17} | \, r, s \text{ integers}\}$, which of the following is irreducible?
(a) $8 + 2\sqrt{7}$ (b) $3 - \sqrt{17}$ (c) $9 - 2\sqrt{17}$ (d) $7 + \sqrt{17}$ (e) $13 + \sqrt{17}$

18. How many topologies are possible on a set of 2 points?
(a) 5 (b) 4 (c) 3 (d) 2 (e) 1

19. In the finite field $\mathbb{Z}_{17}$, what is the multiplicative inverse of 10?
(a) 13 (b) 12 (c) 11 (d) 9 (e) 7

Linear Algebra

1. Let $M = \begin{bmatrix} 1 & 2 \\ 3 & 9 \end{bmatrix}$. The determinant of the adjoint of M is
   (a) 9 (b) 6 (c) 27 (d) 18 (e) 3

2. Let $M = \begin{bmatrix} 6 & 10 \\ -2 & -3 \end{bmatrix}$. The trace of M^5 equals
   (a) 27 (b) 3^5 (c) 5^3 (d) $6^5 + (-3)^5$ (e) 33

3. The degree of the minimum polynomial satisfied by a nonscalar, 8 by 8, idempotent matrix M is
   (a) 4 (b) 2 (c) 8 (d) 3 (e) 6

4. The Wronskian of $f_1(x) = x^2 \sin(x)$ and $f_2(x) = x^2 \cos(x)$ is
   (a) x^2 (b) $-x^2$ (c) x^4 (d) $-x^4$ (e) $2x^4$

5. The dimension of the null space of

$$M = \begin{bmatrix} 1 & 2 & -1 & 0 \\ 3 & 2 & 0 & 1 \\ 1 & 2 & 0 & 2 \\ -1 & 0 & 1 & 3 \end{bmatrix}$$

is:
   (a) 2 (b) 1 (c) 4 (d) 3 (e) 0

6. The eigenvalues which corresponds to the eigenvector $\langle 3, 2 \rangle$ for $M = \begin{bmatrix} 1 & -3 \\ -2 & 2 \end{bmatrix}$ is
   (a) 1 (b) 4 (c) -1 (d) -4 (e) 2

7. Let $M = \begin{bmatrix} 2 & 4 \\ 1 & 2 \end{bmatrix}$. Then $M^6 = kM$ for $k =$
   (a) 2^6 (b) 2^8 (c) 2^{10} (d) 2^{12} (e) 2^{14}

8. The cross product $\vec{u} \times \vec{v}$ of the vectors $\vec{u} = 2\vec{i} - \vec{j} + 3\vec{k}$ and $\vec{v} = \vec{i} + 2\vec{j} - \vec{k}$ is given by
   (a) $7\vec{i} + \vec{j} + 3\vec{k}$ (b) $5\vec{i} + 5\vec{j} + 3\vec{k}$ (c) -3 (d) $-5\vec{i} + 5\vec{j} + 5\vec{k}$ (e) $7\vec{i} - \vec{j}$

9. Let T be a linear transformation of the plane such that $T(1,1) = (-1,1)$ and $T(2,3) = (1,2)$. Then $T(2,4)$ equals
   (a) $(4,2)$ (b) $(2,-4)$ (c) $(3,-2)$ (d) $(2,4)$ (e) $(-3,2)$

10. Let T represent a nonsingular linear transformation from $\mathbb{E}^n$ into $\mathbb{E}^n$. Which of the following is not true?
   (a) Null space of $T = \{0\}$
   (b) T is one-to-one
   (c) Dimension of null space is zero: Dim $N(T) = 0$
   (d) Dimension of range space is n: Dim $R(T) = n$

(e) Dim $N(T^{-1}) = \text{Dim}R(T)$

11. The inverse of the matrix $M = \begin{bmatrix} 2 & 1 & 3 \\ 0 & -1 & 2 \\ 4 & 3 & 1 \end{bmatrix}$ is the matrix $M^{-1} = \frac{1}{6}\begin{bmatrix} -7 & 8 & a \\ 8 & -10 & -4 \\ 4 & b & -2 \end{bmatrix}$ where

(a) $a = 5; b = -2$ (b) $a = 3; b = 2$ (c) $a = 1; b = -3$ (d) $a = 2; b = -3$ (e) $a = 2; b = 3$

12. Given that S and T are subspaces of a vector space, which of the following is also a subspace?

(a) $S \cap T$ (b) $S \cup T$ (c) $2S$ (d) Both (a) and (c) (e) Both (b) and (c)

13. In a homogeneous system of 5 linear equations in 7 unknowns, the rank of the coefficient matrix is 4. What is the maximum number of independent solution vectors to the system?

(a) 5 (b) 2 (c) 4 (d) 1 (e) 3

14. If A is an $n \times n$ matrix with diagonal entries all a, and all other entries b, then one eigenvalue of A is $a - b$. Find another eigenvalue of A.

(a) $b - a$ (b) $nb + a - b$ (c) $nb - a + b$ (d) 0 (e) None of these

15. Find k so that the matrix

$$A = \begin{bmatrix} k & 1 & 2 \\ 1 & 2 & k \\ 1 & 2 & 3 \end{bmatrix}$$

has eigenvalue $\lambda = 1$.

(a) $\dfrac{1}{2}$ (b) $-\dfrac{1}{2}$ (c) 0 (d) 1 (e) -1

Complex Analysis

1. The fixed point(s) of the Möbius transformation $w(z) = \dfrac{z-2}{z-1}$ is (are)
   (a) $1 \pm \sqrt{3}$ (b) $1 \pm 2i$ (c) $2i$ (d) $1 \pm i$ (e) $-1 \pm \sqrt{2}i$

2. The sum of the 9^{th} roots of unity is
   (a) 0 (b) 1 (c) 9 (d) 10 (e) $1 + i$

3. The value of $I = \displaystyle\oint_c \frac{\cos(z)}{z(z-\pi)}\, dz$ where C is the circle $|z-1| = 2$ is
   (a) 0 (b) $2i$ (c) $-2i$ (d) $-4i$ (e) $4i$

4. If $i = \sqrt{-1}$, then $\displaystyle\sum_{j=0}^{10} (-i)^j$ is
   (a) i (b) -1 (c) $-i$ (d) $1 + i$ (e) $i - 1$

5. The function $f(x) = \sin(x)\cosh(y) + v(x, y)i$ is analytic for $v(x, y)$ equal to
   (a) $\cos(x)\cosh(y)$ (b) $\cos(x)\sinh(y)$ (c) $-\sin(y)\cosh(x)$ (d) $\sin(x)\sinh(y)$
   (e) $\sin(y)\cosh(x)$

6. Find the point $x + iy$ at which the complex function $f(x + iy) = x^2 + y^2 + 2xi$ is differentiable.
   (a) 0 (b) i (c) $i - 1$ (d) $1 + i$ (e) $-i$

7. Express z^{14} in the form $a + bi$ if $z = \dfrac{1+i}{\sqrt{2}}$.
   (a) $-i$ (b) -1 (c) 1 (d) i (e) $\dfrac{1+i}{128}$

Miscellaneous

1. The graph of the arccosine function is the graph of the arcsine function
   (a) translated horizontally $\pi/2$ units to the right.
   (b) first reflected in the horizontal axis and then translated vertically $\pi/2$ units upward
   (c) first translated horizontally $\pi/2$ units to the left and then reflected in the horizontal axis
   (d) first translated vertically $\pi/2$ units downward and then reflected in the vertical axis
   (e) translated horizontally $\pi/2$ units to the left

2. The domain of $f(x) = \dfrac{\sqrt[3]{x+2}}{x-6}$ is given by
   (a) $(6, \infty)$ (b) $[-2, \infty)$ (c) $\mathbb{R} - \{-2, 6\}$ (d) $[-2, \infty) - \{6\}$ (e) $\mathbb{R} - \{6\}$

3. Let x be a random variable possessing the probability density function

$$f(x) = \begin{cases} cx, & x \in [0, 10] \\ 0, & \text{otherwise} \end{cases}$$

where $c \in \mathbb{R}$. The probability that $x \in [1, 2]$ is
   (a) $\dfrac{1}{100}$ (b) $\dfrac{3}{100}$ (c) $\dfrac{5}{100}$ (d) $\dfrac{7}{100}$ (e) $\dfrac{9}{100}$

4. Let the variable X have the probability density function

$$f(x) = \begin{cases} 1 - \frac{x}{2}, & x \in (0, 2) \\ 0, & \text{otherwise} \end{cases}$$

The expected value of the random variable X^2 is
   (a) $\dfrac{1}{3}$ (b) $\dfrac{5}{6}$ (c) $\dfrac{1}{2}$ (d) $\dfrac{1}{6}$ (e) $\dfrac{2}{3}$

5. Which of the following is not equal to $f(x) = \dfrac{x+1}{x-1}$ when both are defined?
   (a) $-f(x^{-1})$ (b) $[f(-x)]^{-1}$ (c) $f^{-1}(x)$ (d) $f^{-1}(x^{-1})$ (e) $\dfrac{1}{2}\left[f^{-1}(x) - f(x^{-1})\right]$

6. Let x, y, z represent Boolean variables. Which of the following is not a Boolean function?
   (a) $f(x, y) = x\sqrt{y}$ (b) $f(x, y, z) = \max\{x, y, z\}$ (c) $f(x, y) = x^2 + y - xy$
   (d) $f(x, y, z) = x + y + z - xy - yz$ (e) $f(x, y, z) = xyz$

7. Let $p(x)$, $q(x)$, and $r(x)$ be open statements relative to the set S. Then $\sim (\exists x \in S)[(p(x) \vee q(x)) \wedge r(x)]$ is equivalent to
   (a) $(\forall x \in S)\{[(\sim p(x)) \vee (\sim q(x))] \vee [\sim r(x)]\}$
   (b) $(\forall x \in S)\{[(\sim p(x)) \wedge (\sim q(x))] \vee [\sim r(x)]\}$
   (c) $(\forall x \in S)\{[(\sim p(x)) \wedge (\sim q(x))] \vee [r(x)]\}$
   (d) $(\forall x \in S)\{[(\sim p(x)) \vee (\sim q(x))] \wedge [\sim r(x)]\}$
   (e) $(\forall x \in S)\{[(\sim p(x)) \vee (\sim q(x))] \wedge [r(x)]\}$

8. Which of the following numbers is divisible by 9?

(a) 7224466 (b) 9224466 (c) 3224466 (d) 5224466 (e) 1224466

9. Which of the following is equivalent to $\sin^3(x)\cos^2(x)$?

(a) $\frac{1}{16}[2\sin(x) - \sin(3x) - 2\sin(5x)]$

(b) $\frac{1}{16}[\sin(x) - 2\sin(3x) - \sin(5x)]$

(c) $\frac{1}{16}[2\sin(x) - \sin(3x) - \sin(5x)]$

(d) $\frac{1}{16}[2\sin(x) + \sin(3x) - \sin(5x)]$

(e) $\frac{1}{16}[\sin(x) + \sin(3x) - \sin(5x)]$

10. Consider the two player (P_1, P_2) game G with payoff matrix

$$\begin{array}{cc} & P_2 \\ P_1 & \begin{bmatrix} 1 & -1 \\ 2 & 3 \end{bmatrix} \end{array}$$

The minimax value of G is

(a) $\frac{5}{3}$ (b) 1 (c) $\frac{3}{2}$ (d) 5 (e) 0

11. From a group of 15 mathematics graduate school applicants, 10 are selected at random. Let P be the probability that 4 of the 5 applicants who would make the best graduate students are included in the 10 selected. Which of the following statements is true?

(a) $0 \le P \le \frac{1}{5}$ (b) $\frac{1}{5} < P \le \frac{2}{5}$ (c) $\frac{2}{5} < P \le \frac{3}{5}$ (d) $\frac{3}{5} < P \le \frac{4}{5}$ (e) $\frac{4}{5} < P \le 1$

12. The decimal $2.0259\overline{259}$ is equivalent to which of the following?

(a) $\frac{20237}{9990}$ (b) $\frac{547}{270}$ (c) $\frac{20239}{9999}$ (d) $\frac{747}{370}$ (e) $\frac{737}{380}$

13. The solution set for the inequality $x - \frac{3}{x} > 2$ is given by

(a) $(0, \infty)$ (b) $(3, \infty)$ (c) $(-1, 0) \cup (3, \infty)$ (d) $(-\infty, 0) \cup (3, \infty)$ (e) $(-\infty, 3)$

14. Let A and B be subsets of U and denote the complement of subset X of U by X^c. Find $[[A \cap (A \cap B^c)] \cap B]^c$.

(a) B^c (b) A^c $A \cup B^c$ (d) U (e) $\emptyset$

15. The number of vertices of an ordinary polyhedron with 12 faces and 17 edges is

(a) 7 (b) 5 (c) 11 (d) 9 (e) 13