$(\neg p \wedge \neg p) \vee (\neg p \wedge q) \longrightarrow \neg q$

∴ It is not a tautology.

PREDICATES AND QUANTIFIERS :-

Q) Let $P(x)$ be the statement $x>3$ what are the truth values of $P(4)$ and $P(2)$

$P(4) : T$

$P(2) : F$

Q) Let $q(x,y)$ be the statement $x = y+3$ what are the truth values of $q(1,2)$ $q(3,0)$

$q(1,2) \rightarrow$ False

$q(3,0) \rightarrow$ true

3) If $x>0$ then $x := x+1$ then $P(1)$

$P(1) : 2$

Quantifiers:

Demorgan's Law for quantifiers:

① $\neg(\forall x P(x)) = \exists x \neg P(x)$

② $\neg(\exists x P(x)) = \forall x \neg P(x)$

③

① $\neg(\forall x P(x))$ is true $\Leftrightarrow$ $\forall x P(x)$ is false..
$\Leftrightarrow$ There exist an element x in domain for which $P(x)$ is false.
$\Leftrightarrow$ There exist an element x in domain for which $\neg P(x)$ is true.
$\Leftrightarrow$ $\exists x \neg P(x)$ is true.

② $\neg(\exists x P(x))$ is true $\Leftrightarrow$ $\exists x P(x)$ is false
$\Leftrightarrow$ for every x in domain for which $P(x)$ is false
$\Leftrightarrow$ for every x in domain for which $\neg P(x)$ is true
$\Leftrightarrow$ $\forall x \neg P(x)$ is true.

Show that $\neg(\forall x(P(x) \to q(x)))$ is equivalent to $\exists x(P(x) \wedge \neg q(x))$

Ans:- ~~$\exists x$~~

$\neg(\forall x(\underbrace{P(x) \to q(x)}_{R(x)}))$ $\Rightarrow$ $\exists x \neg R(x)$

$\Rightarrow \exists x \neg(P(x) \to q(x))$ $\qquad P \to q \equiv \neg p \vee q$

$\Rightarrow \exists x\ P(x) \wedge \neg q(x)$

What are the negation of the statement.

1) There is an honest politician. All Americans eat Burgers.

~~$\exists x$~~ Every politican is dishonest.

There exists an americans who doesn't eat Burgers.

Q) Let $P(x)$ is the statement. x spends more than 5 hours a week. Every week day in class. where the domain of x consists of all students express each of the following quantifications in English.

1) $\exists x P(x)$ 2) $\forall x P(x)$ 3) $\exists x \neg P(x)$ 4) $\forall x \neg P(x)$

1) There exist a student who spends more than 5 hours every week day in a class.

2) All students spend more than 5 hours every week day in a class

3) There exists a student who doesn't spend more than 5 hours every week day in a class.

4) ~~All~~ Every students doesn't spend more than 5 hours every week day in a class

Q) Let $P(x)$ be the statement $x = x^2$ if the domain consists of integers. what are the truth values

1) $P(0) \rightarrow$ True 2) $P(1) \rightarrow$ True 3) $P(2)$ = false 4) $P(-1)$ = false.

5) $\exists x P(x) \rightarrow$ True 6) $\forall x P(x) \rightarrow$ False

Q) Determine the truth values of each of the following statements if the domain consists of all integers.

1) $\forall n (n+1 > n) \rightarrow$ True 2) $\exists n (2n = 3n) \rightarrow$ True.

$\exists n (n = -n) \longrightarrow$ True. (4) $\forall n (n^2 \geq n) \rightarrow$ True.

Q) Suppose that the domain of $P(x)$ consists of the integers $\{1, 2, 3, 4, 5\}$

Express the following statements without using quanti[fiers] instead using only negations, $\wedge$, $\vee$.

$\exists x P(x) \equiv P(1) \vee P(2) \vee P(3) \vee P(4) \vee P(5)$

$\forall x P(x) \equiv P(1) \wedge P(2) \wedge P(3) \wedge P(4) \wedge P(5)$

$\neg \exists x P(x) \equiv \forall x \neg P(x) = \neg P(1) \wedge \neg P(2) \wedge \neg P(3) \wedge \neg P(4) \wedge \neg P(5)$

$\neg(\forall x P(x)) \equiv \exists x \neg P(x) = \neg P(1) \vee \neg P(2) \vee \neg P(3) \vee \neg P(4) \vee \neg P(5)$

* $\forall x((x \neq 3) \to P(x)) \vee \exists x P(x)$ Represent using $\vee$, $\wedge$

Rules of inference :

An argument in propositional logic is a sequence of proposition. All but the final proposition in the argument is called premises and final proposition in the argument is called conclusion.

An argument is valid if the truth of all premises $\to$ the truth of conclusion

$$\underbrace{P_1, P_2, \ldots P_n}_{\text{premises}} \quad \underset{\text{conclusion}}{\underset{\Downarrow}{q}}$$

Rules of inferences :-

p: "you score 40 marks in calculus".
q: you will pass the calculus exam".
r: you will successfully complete the course."

$p \to q$ $\quad$ $p \to$ premises $\quad$ $q \to$ conclusion.

Rules of inference	Tautology	Name
$\begin{array}{l} p \\ p \to q \\ \hline \therefore q \end{array}$	$(p \wedge (p \to q)) \to q$	Modus ponens
$\begin{array}{l} \neg q \\ p \to q \\ \hline \neg p \end{array}$	$(\neg q \wedge (p \to q)) \to \neg p$	Modus tollens
$\begin{array}{l} p \to r \\ q \to r \\ \hline p \to r \end{array}$	$((p \to q) \wedge (q \to r)) \to (p \to r)$	Hypothetical syllogism
$\begin{array}{l} p \vee q \\ \neg p \\ \hline q \end{array}$	$((p \vee q) \wedge \neg p) \to q$	Disjunctive syllogism

$\frac{p}{\therefore p \vee q}$ $\quad p \to (p \vee q)$ Addition.

$\frac{p \wedge q}{p}$ $\quad (p \wedge q) \to p$ simplification

$\frac{p \quad q}{\therefore p \wedge q}$ $\quad (p) \wedge (q) \to (p \wedge q)$ conjunction

$\frac{p \vee q \quad \neg p \vee r}{q \vee r}$ $\quad (p \vee q) \wedge (\neg p \vee r) \to (q \vee r)$ Resolution.

suppose that

p: If it snows today they will go skeing.

q: It is snowing today.

what conclusion we can make?

$p \to q$

p

(Modus ponens)

* Determine whether the argument given here is valid and determine whether its conclusion must be true because validity of the argument.

A: If $\sqrt{2} > 3/2$ then $(\sqrt{2})^2 > (3/2)^2$. we know that $\sqrt{2} > 3/2$. consequently $(\sqrt{2})^2$ is greater than $(3/2)^2$. conclusion.

It's an valid argument using modus ponens

* State which rule of inference is the bases of the following argument

1) It is below freezing now. Therefore it is either below freezing or raining. $\to$ Addition

* State which rule of inference is the basis of the following argument

It is below freezing now and raining now therefore it is freezing now

(Simplification)

* If it rains today then we will not have a bbq today. If we do not have a bbq today then we will have a bbq tomorrow Therefore If it rains today then we will have a bbq tommorow.

(Hypothetical syllogism)

1) show that the hypothesis "if it is not sunny this afternoon and it is colder than yesterday. 2) we will go swimming only if its sunny.

3) If we don't go to swimming then we will take a trip.

4) And If we take a trip, then we will be home by sunset.

Lead to the conclusion, we will be home by sunset.

A) All the above can be written as

Note:
p only if q
$p \to q$

p : It is sunny this afternoon
q : It is colder than yesterday
r : we will go swimming
s : we will take a trip
t : we will be home by sunset.

$\left.\begin{array}{l} \neg p \wedge q \\ r \to p \\ \neg r \to s \\ s \to t \end{array}\right\}$ premises

t } conclusion

$\neg p \wedge q$	(H)	$\neg r \to s$	(H)
$\neg p$	(Simplification)	s	(Modus ponens)
$r \to p$	(H)	$s \to t$	(H)
$\neg r$	(Modus tollens)	t	(Modus ponens)

show that the hypothesis If you send me an img message then I'll finish writing the program. If you don't send me an e-mail, then I'll go to sleep early. If I go to sleep early then I'll wake up feeling refresh lead to the conclu If I don't finish writing the program, then I will wake up feeling refreshed.

sol: p: you send me a email message

q: I'll finish writing the program

r: I'll go to sleep early

s: I'll wake up feeling refreshed.

$p \rightarrow q$

$\neg p \rightarrow r$

$r \rightarrow s$ } Premises

$\neg q \rightarrow s$ → conclusion

take $p \rightarrow q$ (Hypotheses)

$\neg q \rightarrow \neg p$ (contrapositive)

$\neg p \rightarrow r$ (Hypothesis)

$\neg q \rightarrow r$ (Hypothetical syllogis)

$r \rightarrow s$

$\neg q \rightarrow s$ (

check whether the prop $(p \rightarrow q) \wedge (q \rightarrow p)$ is a tautology or not.

truth table

p	q	$p \rightarrow q$	$q \rightarrow p$	$(p \rightarrow q) \wedge (q \rightarrow p)$
T	T	T	T	T
T	F	F	T	F
F	T	F	F	F
F	F	T	T	T

Not a tautology

$(p \rightarrow q)$	$\wedge p$	$\rightarrow q$
T	T	T
F	F	T
T	T	T
F	F	T

a tautology.

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Rules of Inference for Quantified statements.

Rules of Inference

$\dfrac{\forall x\, P(x)}{\therefore P(c) \text{ for any } c}$	Universal Instantiation
$\dfrac{P(c) \text{ for any arbitrary } c}{\forall x\, P(x)}$	universal generalization
$\dfrac{\exists x\, P(x)}{\therefore P(c) \text{ for some } c}$	Existential Instantiation.
$\dfrac{P(c) \text{ for some } c}{\therefore \exists x\, P(x)}$	Existential generalisation:

: show that the predecessor "$\overset{P(x)}{\text{everyone in D.M class}}$ has taken a course in $\overset{Q(x)}{\text{CS}}$ and john is a student in the class." (x) Imply the conclusion, john has taken a course in cs.

1) $\forall x\, P(x) \longrightarrow Q(x)$

John is a student in d.m class

$P(john)$

Conclusion : $Q(john)$

$\forall x(P(x) \to Q(x))$ (Hypothesis)

$P(john) \to Q(john)$ (universal Instatiation)

$P(john)$ (Hypothesis)

$Q(john)$ (Modus ponens)

* show that the premises, "A student in the class has not read the book." "Everyone in the class passed the 1st exam." → the conclusion someone who passed the first exam has not read the book.

~~$\exists x P(x) \to Q(x)$~~

$P(\cancel{student}) \to Q(x)$ (Existential ~~Instatition~~)

~~$Q(student)$~~

$\exists x\, P(x) \wedge \neg Q(x)$
$\forall x(P(x) \to R(x))$ } premises

$\exists x(\neg Q(x) \wedge R(x))$ } conclusion

from $\exists$ Instatitiation

(2) $P(c) \wedge \neg Q(c)$ for some c

(3) $\neg Q(c)$ for some c (simplification)

(4) $\forall x(P(x) \to R(x))$ (H)

(5) $P(c) \to R(c)$ for any c (universal Instatitiation)

(6) $P(c)$ (simplification of 2)

(7) $R(c)$ (Modus ponens)

(8) $\neg Q(c) \wedge R(c)$ for any c (conjunction 3 & 7)

(9) $\exists x(\neg Q(x) \wedge R(x))$ (Ex generali)

INTRODUCTION TO THEOREM:

Direct proof:

① for every real no x and y, if $x > y$ then $x^2 > y^2$

if $x > y$ and $x \& y$ are real no's then $x^2 > y^2$.

* Give a direct proof of the theorem "if n is an odd integer then n^2 is odd."

$\forall n\, P(n) \longrightarrow Q(n)$

$P(n)$: "n is odd" $Q(n)$: "n^2 is odd".

$P(c) \longrightarrow Q(c)$ for arbitrary integer c.

* Proof: Suppose n is odd,

∃ an integer k ∋ $n = 2k+1$

$n^2 = 4k^2+4k+1$

$= 2(2k^2+2k)+1$

$= 2m+1$

* Give a direct proof that if m and n are both perfect squares then nm is also a perfect square.

Suppose m and n are perfect squares

we can write $m = k \times k$ $n = z \times z$

∃ an integers k and z ∋ $m = k \times k$; $n = z \times z$

$nm = k \times k \times z \times z$ (c.o. Real no's satisfies)

$nm = k \times z \times k \times z$

y y where $y \in$ integer.

$nm = y^2$ $y^2 \in$ integer.

Prove that if n is an Integer and $3n+2$ is odd then n is odd.

$p(x)$: n is an integer ~~then~~ & $3n+2$.

q : n is odd.

$3n+2 = 2k+1$

$3n = 2k-1$

$3n = 2(k-1)+1$

$3n = 2m+1$

we can't prove this using this direct proof method.

. Method of contra~~diction~~position

Suppose n is even

If n is even then $3n+2$ is even

$n = 2k$ for some integer k

$3n = 6k$

$3n+2 = 6k+2$

$3n+2 = 2\underbrace{(3k+1)}_{\text{integer}}$

$= 2m$

even

Therefore by the method of contra~~diction~~position If n is an integer and $3n+2$ is odd then n is odd.

<u>Method of contradiction:-</u>

* prove that $\sqrt{2}$ is irrational.

consider : suppose $\sqrt{2}$ is rational.

$\sqrt{2} = p/q$ [where p and q have no common factors and $q \neq 0$]

$2 = \frac{p^2}{q^2}$

$2q^2 = p^2$

~~p^2 and q^2 are~~ .

p^2 is a multiple of q^2 and 2

p^2 is an even no then p is an even number.

$\exists$ an integer $K \ni p = 2K$

$\cancel{4}K^2 = \cancel{2}q^2$

$2K^2 = q^2$.

$\therefore q^2$ is an multiple of 2

q^2 is an even no then q is an even number.

$\therefore$ P and q are multiples of 2 and both have a common factor '2'

Therefore our assumptions contradicts with the standard fact.

Hence through method of contradiction $\sqrt{2}$ is an irrational.

show that $\sqrt{x}^{\sqrt{x}}$ need not to be an irrational number.

suppose $\sqrt{x}^{\sqrt{x}}$ is an irrational number where.

$= \left((\sqrt{x})^{\sqrt{x}}\right)^{\sqrt{x}}$

$= (\sqrt{x})^2$

$= x^{(1/2)x}$

$= x$ is an rational.

$\therefore \sqrt{x}^{\sqrt{x}}$ need not to be an irrational number.

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FUNCTIONS

A function from a set X to another set Y is a rule that assigns to each other element in X a unique element in Y.

$f: X \rightarrow Y$ (from X to Y)

domain: X, codomain: Y

Ex: $f(x) = x$; $f: R \rightarrow R$

$f(x) = x+1$

$f(x) = ax+b \longrightarrow$ linear function

$f(x) = x^n \longrightarrow$ power function

$f(x) = a^x \longrightarrow$ exponential function

ONE TO ONE AND ONTO FUNCTIONS :-

ONE TO ONE (INJECTION) :-

$f: x \rightarrow y$ Let x_1 and x_2 be any 2 elements from X. if $f(x_1) = f(x_2) \Longrightarrow x_1 = x_2$ then f is injective. (Horizontal line Test)

ONTO or SURJECTION :-

A function $f: X \rightarrow Y$ is said to be onto (or surjective) . If for every $y \in Y$ there exist a $x \in X$ such that $f(x) = y$.

BIJECTION (one-one correspondence) :-

A function $f: X \rightarrow Y$ is said to be a bijection if it is both one-on and onto.

Example :-

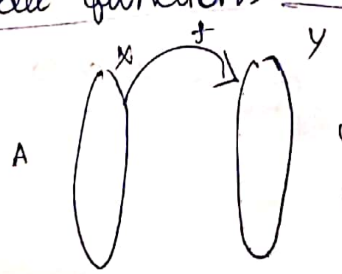
$f(x) = 1/x$ $R \rightarrow R$ at $x = 0$ It's not defined.

Not a function.

$f(x) = \sqrt{x}$ $R \rightarrow R \rightarrow$ Not a function.

* Increasing fun, Decreasing fun strictly Increasing, strictly decre periodic functions.

Note :-



Let X and Y be two sets and let f be a fn from X. ~~and~~ to Y

Let $A \subseteq X$ then Image $(A) = \{ y \in Y : y = f(x)$ for $x \in A \}$

Inverse function :

$y \in Y \quad \exists\, x \in X$

$\left\{ \begin{array}{l} g(y) = x \\ f(x) = y \end{array} \right.$ Inverse

prove that $y = x+1$ is a bijection.

One to one :-

$f(x_1) = f(x_2) \Rightarrow x_1 + 1 = x_2 + 1 \Rightarrow x_1 = x_2$

$\therefore$ It is one-one.

onto :-

$y = x+1 \quad R \to R$

$y - 1 = x \in R \to R$

$f(y-1) = y - 1 + 1 = y$

* check whether $f(x) = x^2$ from $R \to R^+ \cup \{0\}$ is one to one and onto

$f(x_1) = f(x_2) \Rightarrow x_1^2 = x_2^2$

$x_1 = \pm x_2 \quad \in$ codomain R^+ $\left[\begin{array}{l} \text{eg: } -1 \neq 1 \\ (-1)^2 = 1^2 \end{array} \right]$

$\therefore$ not one to one.

ONTO :-

Let $y \in R^+ \cup \{0\}$ ($\because$ choose any arbitrary element from codomain)

$x = \sqrt{y} \in R$

$f(\sqrt{y}) = (\sqrt{y})^2 = y$

$f(x) = x^2$

$y \quad x$

$\left[\because y = x^2 \atop \pm\sqrt{y} = x \right)$

* check whether $y = 1/x$ from $R \to R$ is one to one or onto.

1) It's not a function on $R \to R$

If $y = 1/x$ from $R - \{0\} \to R$

$y_1 = y_2 \Rightarrow \frac{1}{x_1} = \frac{1}{x_2} \Rightarrow x_1 = x_2$

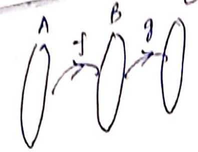
$\therefore$ one-one.

$x = 1/y$

$f(1/y) = y$ not onto. as 0 is an real number but 0 has no preimage.

* We can only find inverse function if and only if its bijective.

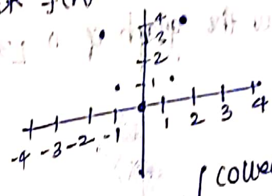
Composition of Function :-



$g\circ f : A \to C$

$g\circ f(x) = g(f(x))$

** $f(n) = n^2 \quad \mathbb{Z} \to \mathbb{Z}$



[collection of points]

Ex:

$f(x) = \sin x \quad f: \mathbb{R} \to \mathbb{R}$

$g(x) = x^2 \quad g: \mathbb{R} \to \mathbb{R}$

$g\circ f(x) = g(f(x)) = g(\sin x) = \sin^2 x$

$f\circ g(x) = f(g(x)) = f(x^2) = \sin x^2$

* floor function

$\lfloor x \rfloor$

$\lfloor 1.2 \rfloor = 1$

$\lfloor -1.2 \rfloor = -2$

* ceiling function

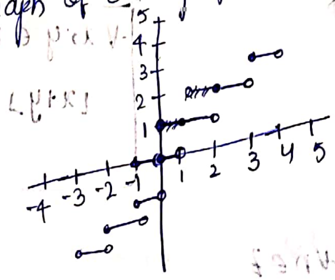
$\lceil x \rceil$

$\lceil 1.2 \rceil = 2$

$\lceil -1.2 \rceil = -1$

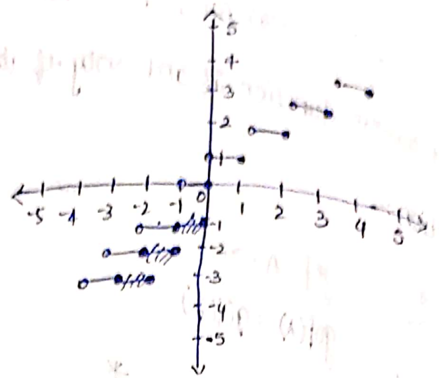
floor $\lfloor x \rfloor = \lceil x \rceil$ if $x \in \mathbb{Z}$

Draw the graph of ceiling function and floor function.

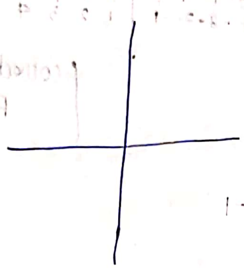


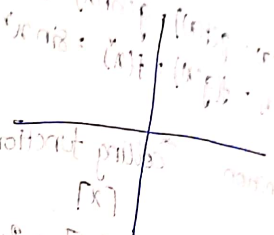
floor function

Ceiling Functions:



** Draw the graph of 1) $\lfloor 3x+2 \rfloor$ 2) $\lceil 2x+1 \rceil$





Properties of ceiling function and floor functions:

* $\lfloor x \rfloor = n \Leftrightarrow n \le x < n+1$ $\qquad x-1 < n \le x$
* $\lceil x \rceil = n \Leftrightarrow n-1 < x \le n$ $\qquad x \le n < x+1$

* floor of $\lfloor -x \rfloor = -\lceil x \rceil \quad \forall x \in \mathbb{R}$

$\lfloor -x \rfloor + \lceil x \rceil = 0$

* $\lceil -x \rceil = -\lfloor x \rfloor$

** $\forall x, y \in \mathbb{R}$

$\lfloor x+y \rfloor = \lfloor x \rfloor + \lfloor y \rfloor$ → False

floor:- $\lfloor x+n \rfloor = \lfloor x \rfloor + n \quad \forall n \in \mathbb{Z}$

$\lfloor x \rfloor = m$

$m \le x < m+1$

$m+n \le x+n < m+n+1$

$\lfloor x+n \rfloor = m+n = \lfloor x \rfloor + n$

* prove that if x is a real no then $\lfloor 2x \rfloor = \lfloor x \rfloor + \lfloor 1/2 + x \rfloor$
* check whether $f(x) = x!$ is a bijective and draw the graph $Z^+ \to Z^+$

A) $\lfloor x \rfloor = n$

$x = n + \varepsilon \quad 0 \le \varepsilon < 1$

case 1: $(0 \le \varepsilon < 1/2)$

$\lfloor x \rfloor = n$

$x = n + \varepsilon$

$x + 1/2 = n + \varepsilon + 1/2$

$< n + 1$

$\lfloor x + 1/2 \rfloor = n$

$2x = 2n + 2\varepsilon$

$< 2n + 1$

$2n \le 2x < 2n + 1$

$\lfloor 2x \rfloor = 2n$

case 2 $(1/2 \le \varepsilon < 1)$

$\lfloor x \rfloor = n$

$x = n + \varepsilon \quad 1/2 \le \varepsilon < 1$

$x + 1/2 = n + \varepsilon + 1/2$

$\ge n + 1$

$\lfloor x + 1/2 \rfloor = n + 1$

$2x = 2n + 2\varepsilon$

$\ge 2n + 1$

$\lfloor 2x \rfloor = 2n + 1$

smallest no

non -ve Z = 0.

positive Z = 1

INDUCTION AND STRONG INDUCTION :-

→ usually we use this to prove for Z^+

Basis step :-

① $P(1)$ is true

Induction step:

② $P(K) \to P(K+1)$ is true

[∴ assume $P(K)$ is true and then prove $P(K+1)$ is true]

STRONG INDUCTION :-

Basis step

1) $P(1)$ is true

Induction step

2) $P(1) \wedge P(2) \wedge \dots \wedge P(K) \longrightarrow P(K+1)$ is true.

Prove that the sum of first n positive integers is $n(n+1)/2$.

$P(n)$ = sum of first n positive integers is $\frac{n(n+1)}{2}$

A) Basis step:-

$P(1)$: sum of 1^{st} integer is $\frac{1(1+1)}{2} = 1$

Induction step:

Assume P(k) is true

i.e. $1+2+\dots+k = \frac{k(k+1)}{2}$ is true

we have to prove P(k+1) is true.

$1+2+\dots+k+k+1 = \frac{(k+1)(k+2)}{2}$

To prove

L.H.S

$(1+2+\dots+k)+k+1$

$\frac{k(k+1)}{2}+k+1$

$\frac{k^2+k+2k+2}{2}$

$\frac{(k+1)(k+2)}{2} = $ R.H.S

Hence by the method of induction. This P is true for all +ve integers.

* Prove that the sum of first n odd integers is n^2

P(1) : sum of first odd int is $n^2 = (1)^2 = 1$

P(1) is true

Induction step:-

Assume P(k) is true

i.e;

$1+3+\dots+2k-1 = k^2$ is true.

We have to prove P(k+1) is true.

$\underline{1+3+\dots+2k-1}+2(k+1)-1 = (k+1)^2$

$k^2+2k+2-1 = (k+1)^2$

$k^2+2k+1 = (k+1)^2$ ∴ LHS = RHS.

product of primes.

* use strong Induction to prove that $\sqrt{2}$ is irrational.

A) For this m there is no $b \in \mathbb{Z}$ such that $\sqrt{2} = m/b$.

$\sqrt{2} \neq 1/b \quad \forall\, b \in \mathbb{Z}$

$\sqrt{2} > 1 \geq 1/b \quad \forall\, b \in \mathbb{Z}$

$\sqrt{2} > 1/b$

$\sqrt{2} \neq 1/b \quad \forall\, b \in \mathbb{Z}$

$\sqrt{2} = \frac{k+1}{b}$

$2 = \frac{(k+1)^2}{b^2}$

$\Rightarrow$ k+1 is even

$k+1 = 2m$ for some $m \in \mathbb{Z}^+$

$(2m)^2 = 2b^2 \Rightarrow b^2 = 2m^2 \Rightarrow b^2$ is even

$\Rightarrow b$ is even

$b = 2s$ for some $s \in \mathbb{Z}$

$\sqrt{2} = \frac{k+1}{b} = \frac{2m}{2s} = m/s$

$\downarrow$

\# contradict.

Show that every positive integer can be expressed as the sum of distinct powers of 2.

To prove some propositions are equal.

check whether the function $f(n) = n!$ one to one and onto

$f : Z^+ \to Z^+$

A) one - one

$f(x_1) = f(x_2)$

$x_1! = x_2!$

$\Rightarrow x_1 = x_2$

$\therefore$ one to one

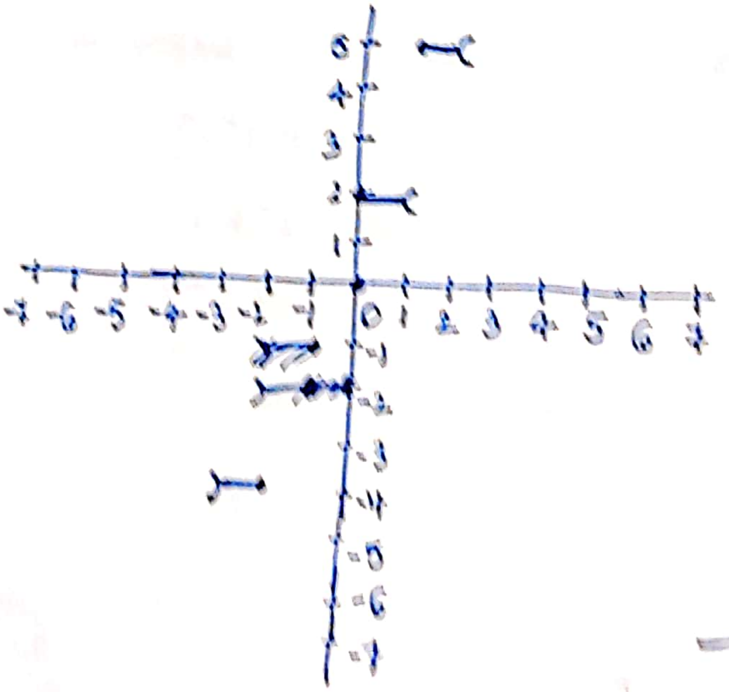
onto

$y = n!$

$f(y) = y!$

$\therefore$ It is not onto.

Draw the graph of $\lfloor 5x+2 \rfloor$



$\lfloor 0.3+2 \rfloor$

$\lfloor -0+2 \rfloor$

$\lfloor -4 \rfloor$

$3x+2$

$x = -2/3$

$x = -0.6$

$\lfloor cx+d \rfloor$

length of the interval $= 1/c$

value at $x = 0$ $= d$