Technological Studies

Intermediate 2 and Higher

Data Booklet

For the use of candidates during coursework and in examinations

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Preface

This data booklet is intended for use by candidates in examinations in Technological Studies at Intermediate 2 and Higher. It is recommended that candidates should become familiar with the contents of the data booklet through use in undertaking units of these courses.

It should be noted that the range of data contained in the booklet has been limited to that syllabus content which may be assessed through written examination papers. This range should be supplemented by other resource material as necessary during the course, eg by using data sheets. However, should any additional information (or data not included in this booklet) be required in an examination, such information will be included in the examination paper.

Teachers/lecturers should note that all of the material contained in this booklet is likely to be examined at some time. This excludes the additional PBASIC commands listed on page 20. With regard to tables of information, not every entry in a table will necessarily be involved in examination questions.

From the variety of data offered in this booklet, candidates will be expected to demonstrate the ability to select an appropriate:

item of information;
formulae;
material property;
operational amplifier circuit;
PBASIC instruction.

Basic Units

Quantity	Symbol	Unit	Abbreviation
Length	ℓ, L	metre	m
Distance	s, x	metre	m
Time	t	second	s
Velocity	v	metre/second	m/s
Mass	m	kilogram	kg
Force	F	newton	N
Work	W	joule	J
Energy	E	joule	J
Power	P	watt (J/s)	W
Stress	σ	newton/metre^2	N/m^2
Strain	∈		
Temperature	T, t	kelvin, celsius	K, °C
Current	I	ampere	A
Voltage	V	volt	V
Resistance	R	ohm	Ω
Frequency	f	hertz	Hz

Decimal Prefixes

prefix	symbol	multiplying factor
tera	T	10^{12}
giga	G	10^{9}
mega	M	10^{6}
kilo	k	10^{3}
milli	m	10^{-3}
micro	μ	10^{-6}
nano	n	10^{-9}
pico	p	10^{-12}

Formulae

Energy and Power

Potential energy	$E_p = mgh$	$g = 9{\cdot}81\ m/s^2$
Kinetic energy	$E_k = \frac{1}{2}mv^2$	
Strain energy	$E_s = \frac{1}{2}Fx$	
Electrical energy	$E_e = VIt$	
Heat energy	$E_h = Cm\,\Delta T$	C is specific heat capacity in J/kgK
Work done	$W = Fs$	
Power	$P = \frac{E}{t}$	
Electrical power	$P = VI = \frac{V^2}{R} = I^2R$	
Mechanical power	$P = Fv$	
	$P = 2\pi nT$	Where T is torque in Nm n is number of rev/s
Torque	$T = Fr$	
Efficiency	$\eta = \frac{E_{out}}{E_{in}} = \frac{P_{out}}{P_{in}}$	
Specific heat capacity of water	$C_w = 4190\ J/kgK$	

Electrical/Electronic

Ohm's law	$V = IR$
Resistors in series	$R_t = R_1 + R_2 + R_3 \cdots\cdots$
Resistors in parallel	$\frac{1}{R_t} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} \ldots\ldots$
for 2 resistors in parallel	$R_t = \frac{R_1 R_2}{(R_1 + R_2)}$
Bi-polar transistor gain	$h_{FE} = \frac{I_c}{I_b}$

Structures

Stress	$\sigma = \frac{F}{A}$	A is the cross-sectional area resisting the applied load
Strain	$\epsilon = \frac{\Delta \ell}{\ell}$	
Stress/strain relationship	$E = \frac{\sigma}{\epsilon}$	E is Young's Modulus
Moment of force	$M = Fx$	x is the perpendicular distance to pivot
Principle of moments	$\Sigma \text{ moments} = 0$	

Factor of Safety (design factor) $= \frac{\text{ultimate load}}{\text{safe working load}} = \frac{\text{ultimate stress}}{\text{safe working stress}}$

Additional Formulae

Area of circle	$A = \frac{\pi d^2}{4}$	d = Diameter
Circumference of circle	$C = \pi d$	

Young's Modulus and Stress

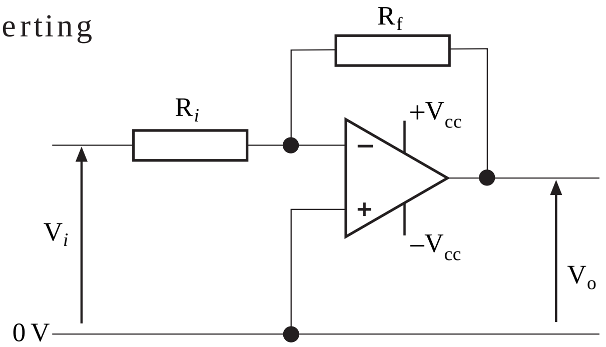
Material	*Young's Modulus* E kN/mm^2	*Yield Stress* σ_Y N/mm^2	*Ultimate Tensile Stress* N/mm^2	*Ultimate Compressive Stress* N/mm^2
Mild steel	196	220	430	430
Stainless steel	190–200	286–500	760–1280	460–540
Low-alloy steels	200–207	500–1980	680–2400	680–2400
Cast iron	120	—	120–160	600–900
Aluminium alloy	70	250	300	300
Soft brass	100	50	80	280
Cast bronze	120	150	300	—
Titanium alloy	110	950	1000	1000
Nickel alloys	130–234	200–1600	400–2000	400–2000
Concrete	—	—	—	60
Concrete (steel reinforced)	45–50	—	—	100
Concrete (post stressed)	—	—	—	100
Plastic, ABS polycarbonate	2·6	55	60	85
Plastic, polypropylene	0·9	19–36	33–36	70
Wood, parallel to grain	9–16	—	55–100	6–16
Wood, perpendicular to grain	0·6–1·0	—	—	2–6
Soda glass	69	3600	—	—
Diamond	1000	50 000	—	—
Gold	82	40	220	—
Ice	9·1	85	—	—

Typical Operational Amplifier Circuits

V_o = output voltage V_i = input voltage V_{cc} = supply voltage

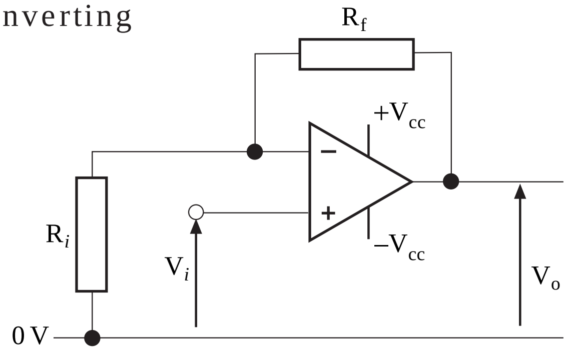
R_f = feedback resistance R_i = input resistance $A_v = \text{gain} = \dfrac{\text{output voltage}}{\text{input voltage}}$

Inverting



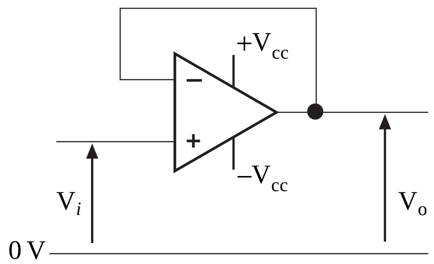
$$A_v = -\frac{V_o}{V_i} \qquad A_v = -\frac{R_f}{R_i} \qquad V_o = -\frac{R_f}{R_i}V_i$$

Non-inverting



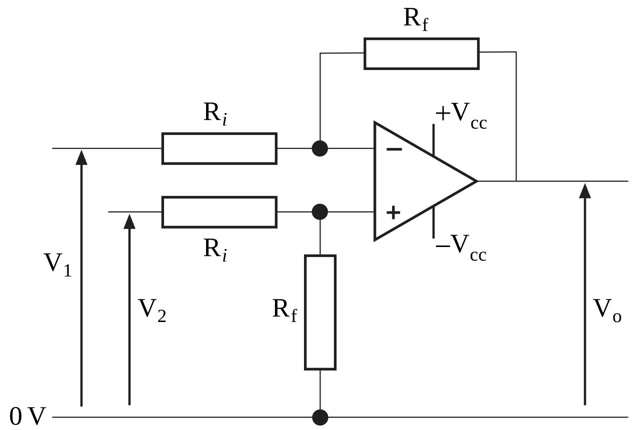
$$A_v = \frac{V_o}{V_i} \qquad A_v = 1+\frac{R_f}{R_i} \qquad V_o = (1+\frac{R_f}{R_i})V_i$$

Voltage Follower



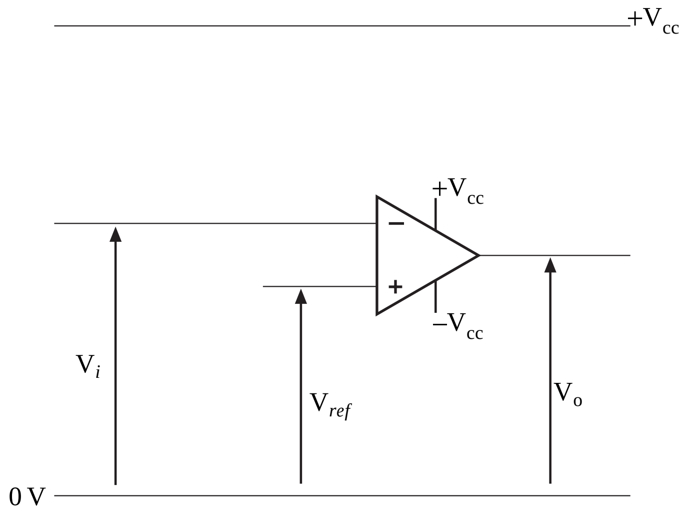
$$V_o = V_i$$

Difference Amplifier



$$A_v = \frac{V_o}{(V_2 - V_1)} \qquad A_v = \frac{R_f}{R_i} \qquad V_o = \frac{R_f}{R_i}(V_2 - V_1)$$

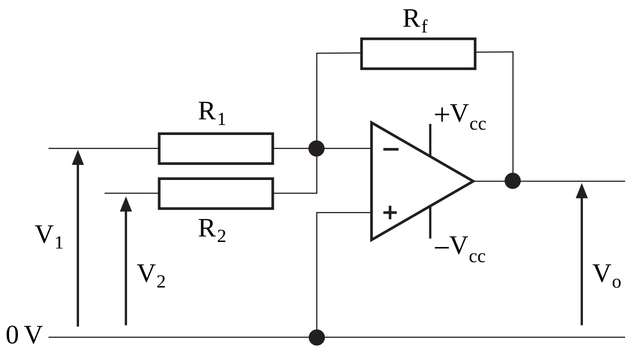
Comparator



If $V_i < V_{ref}$ $\quad V_o = +V_{cc}$

If $V_i > V_{ref}$ $\quad V_o = -V_{cc}$

Summing Amplifier



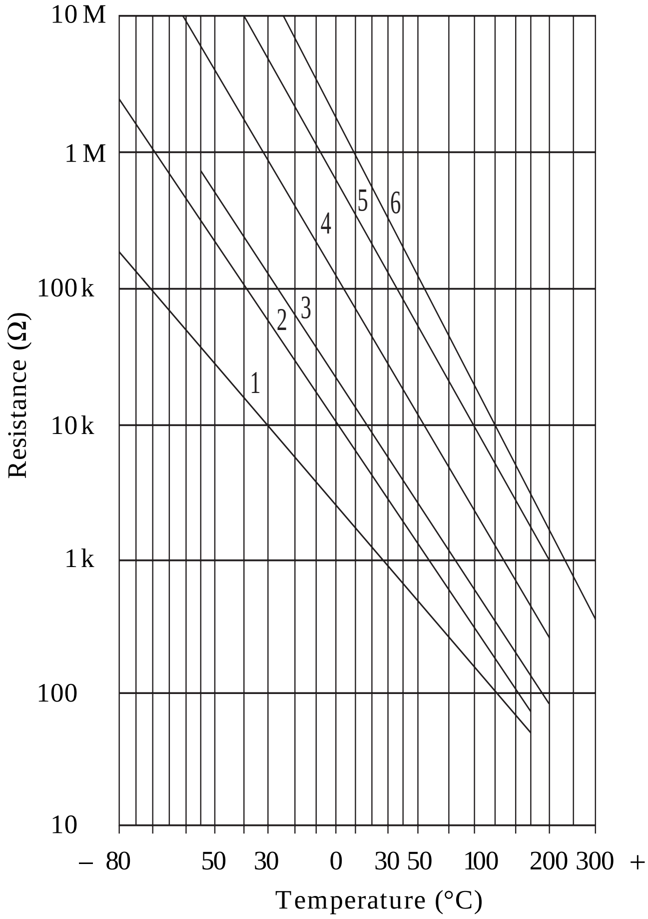
$$A_{v1} = -\frac{R_f}{R_1} \qquad A_{v2} = -\frac{R_f}{R_2} \qquad A_{vn} = -\frac{R_f}{R_n}$$

$$V_o = (A_{v1}V_1) + (A_{v2}V_2) + \cdots\cdots$$

$$V_o = -R_f\left(\frac{V_1}{R_1} + \frac{V_2}{R_2} + \cdots\cdots\right)$$

Graphs for Thermistors, Thermocouple and LDR

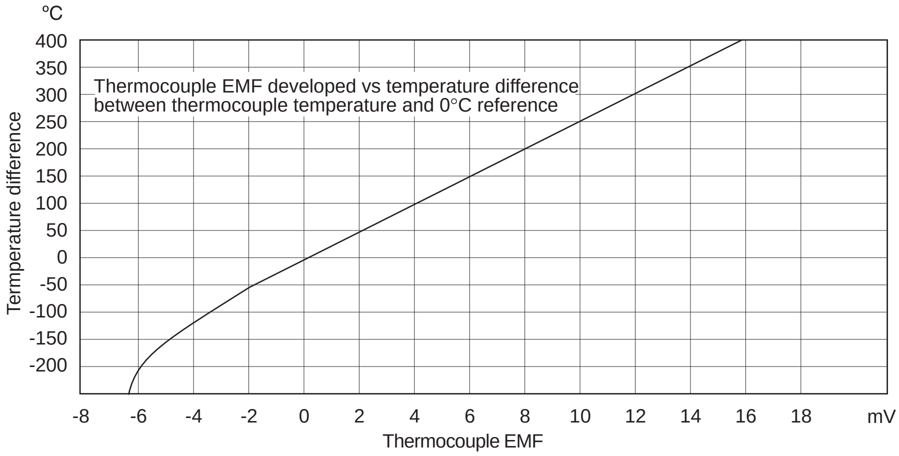
Thermistors



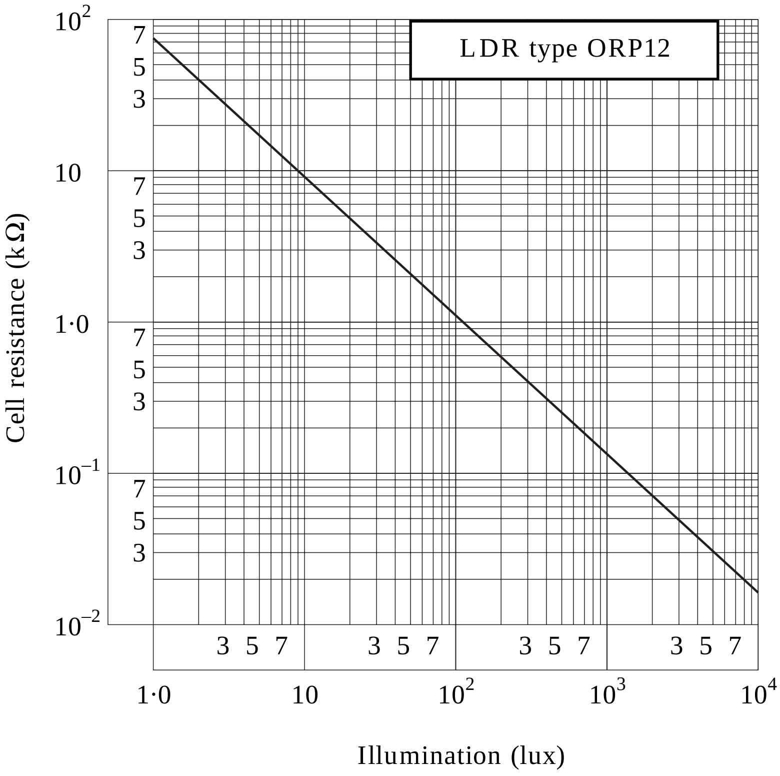
Thermistor Types	
1	151–136
2	151–142
3	256–045
4	151–158
5	256–051
6	151–164

Thermocouple

Typical temperature gradient for type K thermocouple



Light Dependent Resistor (LDR)



Binary Weighting of Data Lines

7	6	5	4	3	2	1	0	Bits
2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0	
128	64	32	16	8	4	2	1	Weighting

Decimal	Binary
0	0000
1	0001
2	0010
3	0011
4	0100
5	0101
6	0110
7	0111
8	1000
9	1001
10	1010
11	1011
12	1100
13	1101
14	1110
15	1111

Symbols for Flow Charts

Data symbol

Data, medium unspecified. Usually used for inputs and outputs.

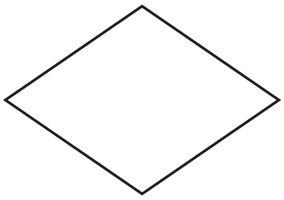
Line symbol

A line represents the flow of data or control. Solid or open arrowheads can be added to indicate direction of flow.

Process symbol

Predefined process consisting of one or more program steps specified elsewhere.

Decision symbol



Decision or switching type of function with a single entry but two alternative exits, only one of which is activated after evaluation of the condition shown in the symbol.

Sub procedure symbol

Entry to or exit from a sub-procedure.

Special symbol

Terminator—an exit to or an entry from the outside environment.

PBASIC Instruction Set for Use at Intermediate 2 level

INPUT/OUTPUT LOW HIGH	 Make pin output and switch it low. Make pin output and switch it high.
TIME PAUSE	 Pause for 0–65535 milliseconds.
LOOPING FOR . . . NEXT	 Establish a FOR–NEXT loop.
PROGRAM FLOW IF . . . THEN GOTO	 Compare and conditionally jump. Jump to address.
SUBROUTINES GOSUB RETURN	 Jump to subroutine at address. Return from subroutine.
NUMERICS LET	 Allocate variables using mathematical equations.
POWER CONTROL END	 Sleep until the power cycles or the computer connects.
MISCELLANEOUS SYMBOL % DIRS	 Allocate a symbol for a variable or value. Set pin conditions to input/output.

PBASIC Instruction Set for Use at Higher level

INPUT/OUTPUT LOW HIGH	 Make pin output and switch it low. Make pin output and switch it high.
TIME PAUSE	 Pause for 0–65535 milliseconds.
LOOPING FOR . . . NEXT	 Establish a FOR–NEXT loop.
PROGRAM FLOW IF . . . THEN GOTO	 Compare and conditionally jump. Jump to address.
SUBROUTINES GOSUB RETURN	 Jump to subroutine at address. Return from subroutine.
NUMERICS LET	 Allocate variables using mathematical equations.
SERIAL I/O SERIN SEROUT	 Receive serial data via a pin. Transmit serial data via a pin.
EEPROM ACCESS EEPROM READ WRITE	 Store data in the EEPROM. Read an EEPROM byte into variable. Write byte into the EEPROM.
POWER CONTROL END	 Sleep until the power cycles or the computer connects.
MISCELLANEOUS DEBUG SYMBOL % DIRS	 Send variables to computer for viewing. Allocate a symbol for a variable or value. Set pin conditions to input/output.

PBASIC Instruction Set —additional instructions normally outwith the scope of Intermediate 2 and Higher

INPUT/OUTPUT	
TOGGLE	Make pin an output and toggle state.
SOUND	Generate tones on a piezo-sounder.
PULSIN	Measure an input pulse.
PULSOUT	Output a timed pulse.
BUTTON	De-bounce a switch input.
INPUT/OUTPUT DIRECTIONS	
INPUT	Make pin an input.
OUTPUT	Make pin an output.
REVERSE	If pin is an output, make it an input, or vice-versa.
PROGRAM FLOW	
BRANCH	Jump to address specified by offset.
NUMERICS	
LOOKUP	Look up stored data in a table.
LOOKDOWN	Find target number in a table and store in a variable.
RANDOM	Generate a random number.
ANALOG I/O	
PWM	Output analogue voltages using a capacitor and resistor.
POT	Measure a potentiometer by charging through a capacitor.
POWER CONTROL	
NAP	Nap for a short period to reduce power consumption.
SLEEP	Sleep for 1–65535 seconds.