



# basic education

Department:  
Basic Education  
**REPUBLIC OF SOUTH AFRICA**

**NATIONAL  
SENIOR CERTIFICATE**

**GRADE 12**

**ELECTRICAL TECHNOLOGY: DIGITAL**

**EXEMPLAR 2018**

**MARKING GUIDELINES**

**MARKS: 200**

**These marking guidelines consist of 10 pages.**

## INSTRUCTIONS TO THE MARKERS

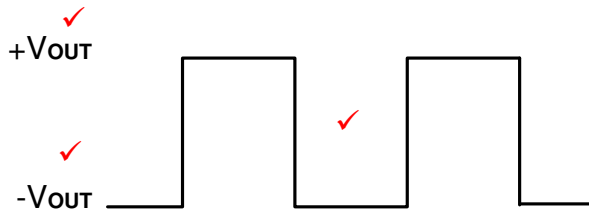
1. All questions with multiple answers imply that any relevant, acceptable answer should be considered.
2. Calculations
  - 2.1 All calculations must show the formulae.
  - 2.2 Substitution of values must be done correctly.
  - 2.3 All answers **MUST** contain the correct unit to be considered.
  - 2.4 Alternative methods must be considered, provided that the correct answer is obtained.
  - 2.5 Where an incorrect answer could be carried over to the next step, the first answer will be deemed incorrect. However, should the incorrect answer be carried over correctly, the marker has to re-calculate the values, using the incorrect answer from the first calculation. If correctly used, the candidate should receive the full marks for subsequent calculations.
  - 2.6 Markers should consider that candidates' answers may deviate slightly from the marking guidelines, depending on how and where in the calculation rounding off was used.
3. These marking guidelines are only a guide with model answers. Alternative interpretations must be considered and marked on merit. However, this principle should be applied consistently throughout the marking session at ALL marking centres.

**QUESTION 1: OCCUPATIONAL HEALTH AND SAFETY (GENERIC)**

- 1.1 Workplace is any premises or place where a person performs work ✓ in the course of his employment. ✓ (2)
  - 1.2 To cooperate with employer or persons to ensure that any duty given by the employer to the employee shall be performed or compiled in accordance with requirements and procedures. ✓  
To take reasonable care of health and safety for himself and other persons who may be affected by his act. ✓ (2)
  - 1.3 Dangerous fumes can accumulate ✓ in the workshop that can be inhaled by people making it an unsafe condition. ✓ (2)
  - 1.4 To review the effectiveness of health and safety measures. ✓  
To identify hazards and potential major incidents at the workplace. ✓ (2)
  - 1.5 Quantitative risk analysis is an attempt to numerically ✓ determine the probabilities of various adverse events and the likely extent of the losses if a particular event takes place. ✓ (2)
- [10]**

**QUESTION 2 : SWITCHING AND CONTROL CIRCUITS**

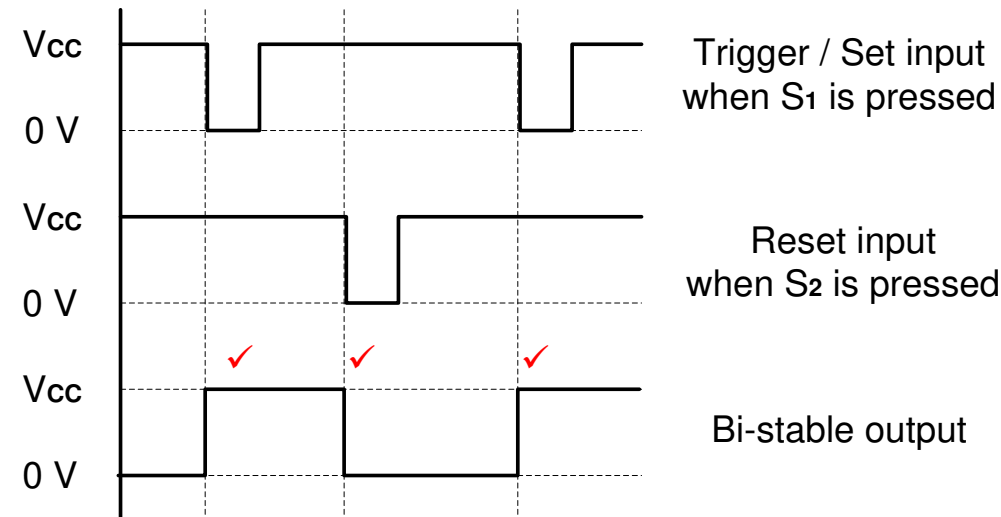
2.1



(3)

2.2 The bi-stable multivibrator is defined as a circuit that is able to give and hold two stable output values, ✓ either high or low ✓ whenever a trigger pulse is received. ✓ (3)

2.3

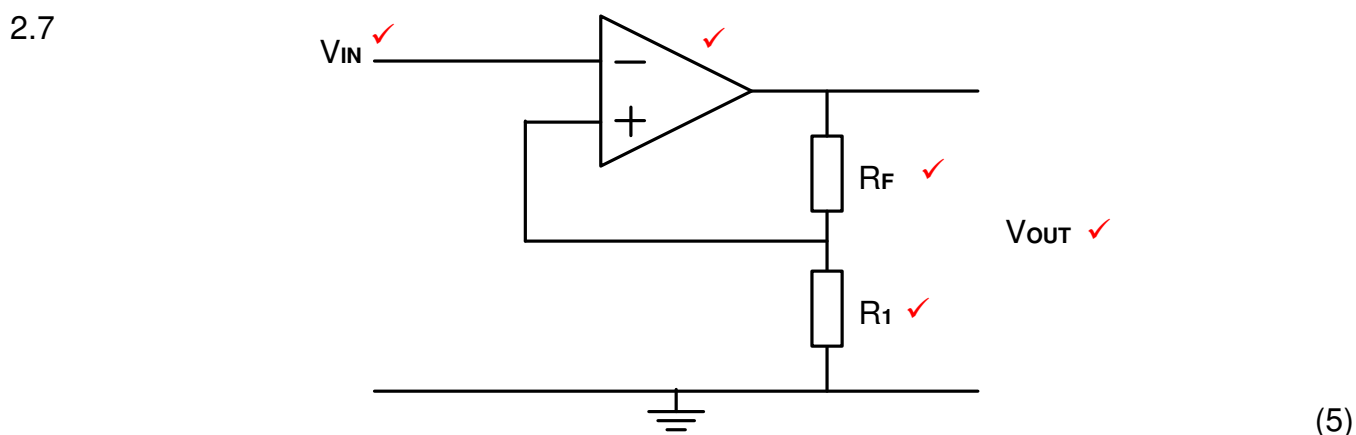


(3)

- 2.4 2.4.1 Contact debouncer ✓ (1)
- 2.4.2  $R_1$  is necessary to prevent pins 6 and 7 ✓ from being directly connected to the positive voltage supply ✓ when  $V_{R_1}$  is set to  $0 \Omega$ . ✓ (3)
- 2.4.3 An increase of  $C_1$  will increase the RC time constant ✓ of the circuit keeping the output at a 'high' or 'on' state for longer. ✓ (2)
- 2.4.4 When S1 is pressed, the input voltage on pin 2 will be pulled down to 0 V. ✓ This triggers the 555 IC ✓ setting the output voltage at pin 3 and pin 7 to high. ✓ Once the capacitor voltage  $V_{C_1}$  reaches  $\frac{2}{3}$  of the supply voltage ✓, it will immediately trip the internal timing circuit to reset the output pin 3 to low or 0 V returning to its stable state. ✓ (5)

- 2.5 Radio receiver filters ✓  
Contact debouncer ✓  
Analogue to digital converter  
Signal recovering (2)

- 2.6 The Schmitt trigger is able to trigger at TWO different voltages. ✓ The moment the input rises above the upper trigger level its output will go to negative saturation ✓ and the moment the input falls below the lower trigger level its output will go to positive saturation. ✓ (3)



- 2.8 2.8.1 Resistor  $R_2$  determines the reference voltage of the comparator ✓ (1)
- 2.8.2 Resistors  $R_1$  and  $R_2$  create a voltage divider ✓ that feeds a reference voltage into the non-inverting input ✓ while its inverting input is usually fed by a transducer. ✓ These two voltages are compared and as soon as the voltage on the inverting input goes higher than the non-inverting input, ✓ the amplifier's output will go into negative saturation. ✓ The moment the non-inverting voltage goes higher than the inverting voltage, the amplifier's output will go into positive saturation. ✓ (6)
- 2.8.3 To adjust the reference voltage the resistor  $R_2$  can be replaced by a variable resistor ✓ (1)

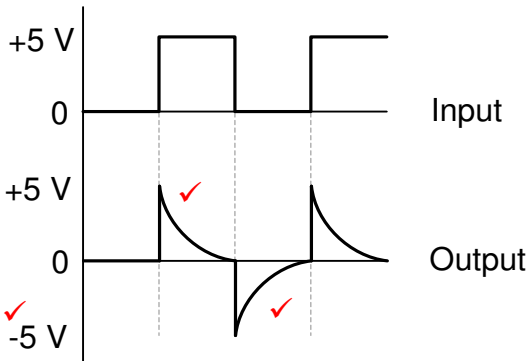
2.9 2.9.1 Inverting ✓ summing amplifier ✓ (2)

2.9.2 Negative feedback ✓ (1)

2.9.3 The gain of the amplifier is determined by the ratio ✓ of the feedback resistor ✓ to the input resistance ✓ of each branch. (3)

2.9.4  $V_{OUT} = -(V_1 + V_2 + V_3)$  ✓  
 $V_{OUT} = -(850 \text{ mV} + 200 \text{ mV} + 950 \text{ mV})$  ✓  
 $V_{OUT} = -2 \text{ V}$  ✓ (3)

2.10 The function of a differentiator is to change a square wave ✓ into a triangular wave. ✓ (2)

2.11 2.11.1  (3)

2.11.2 A long time constant will cause the capacitor to discharge slower ✓ causing the output signal to become more like a distorted square wave. ✓ (2)

2.12 2.12.1 Inverting ✓ integrator (2)

2.12.2  (2)

2.12.3 The higher the frequency for a particular time constant, the better the shape, ✓ but the smaller its amplitude. ✓ (2)

**[60]**

### QUESTION 3: SEMICONDUCTOR DEVICES

- 3.1 3.1.1 A - Non-inverting input ✓  
B - Inverting input ✓ (2)
- 3.1.2 High gain ✓  
High input resistance ✓  
Low output resistance ✓  
Wide bandwidth (3)
- 3.1.3 Open loop gain ✓  
Closed loop gain (1)
- 3.1.4 It is important for the op-amp to have a dual voltage supply to be able to amplify all signals above 0 V ✓ and below 0 V ✓ (positive and negative signals) (2)
- 3.2 3.2.1  $A_V = -\frac{R_F}{R_{IN}}$  ✓  
 $= -\frac{2000}{220}$  ✓  
 $= -9,09$  ✓ (3)
- 3.2.2  $V_{OUT} = V_{IN} \times \left(-\frac{R_F}{R_{IN}}\right)$  ✓  
 $= 0,55 \times \left(-\frac{2000}{220}\right)$  ✓  
 $= -5 \text{ V}$  ✓ (3)
- 3.2.3 If the value of the feedback resistor is increased to 20 kΩ the gain of the amplifier will increase to -90.9 ✓ and the output voltage will increase to -50 V, therefore the output will be saturated. ✓ (2)
- 3.3 Timing functions (turning a light on and off for a prescribed time) ✓  
Creating a warning light ✓  
Pulse, oscillation and signal generation  
Digital logic probes  
Controlling the positioning of a servo device (2)
- 3.4 3.4.1 Pin 6 (threshold) sets the voltage ✓ at which the 555 IC will trigger. ✓ (2)

**[20]**

**QUESTION 4: DIGITAL AND SEQUENTIAL DEVICES**

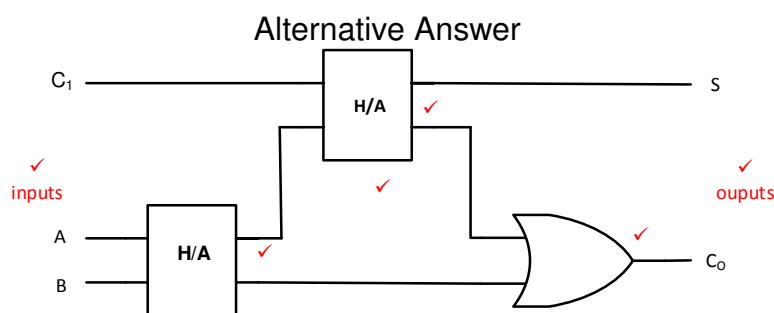
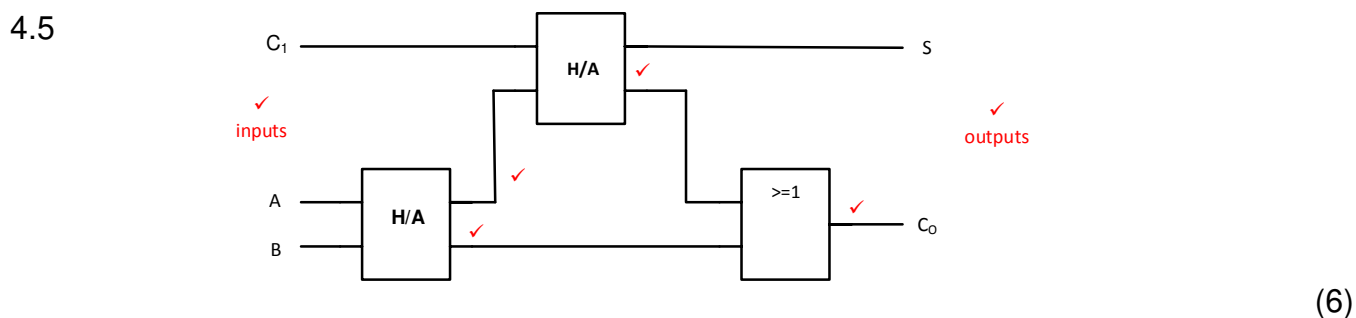
4.1 Liquid Crystal Display (LCD). ✓ (1)

4.2 A sinking output has the transistor collector ✓ connected to the LED's cathode. ✓  
A sourcing output has the transistor emitter ✓ connected to the LED's anode. ✓ (4)

4.3 The function of a decoder is to convert binary code ✓ to decimal code. ✓ (2)

4.4 4.4.1  $C_o = \bar{A} B C + A \bar{B} C + A B \bar{C} + A B C$  ✓ (1)

4.4.2  $C_o = \bar{A} B C + A \bar{B} C + A B \bar{C} + A B C$  ✓  
 $C_o = \bar{A} B C + A \bar{B} C + A B (C + \bar{C})$  ✓  
 $C_o = \bar{A} B C + A \bar{B} C + A B$  ✓  
 $C_o = \bar{A} B C + A (\bar{B} C + B)$  ✓  
 $C_o = \bar{A} B C + A C + A B$  ✓  
 $C_o = C(A + \bar{A} B) + A B$  ✓  
 $C_o = AC + BC + AB$  ✓ (4)



4.6 Combinational logic circuits use AND, OR and NOT gates ✓ as their basic elements. ✓  
Sequential logic circuits involve timing and memory devices ✓ and rely on the FLIP-FLOP as their basic building elements. ✓ (4)

4.7

MODE OF OPERATION	INPUTS		OUTPUTS	
	S	R	Q	$\bar{Q}$
ILLEGAL	0	0	0	0 ✓
SET	0	1	1	0 ✓
RESET	1	0	0	1 ✓
HOLD	1	1	No change ✓	

(4)

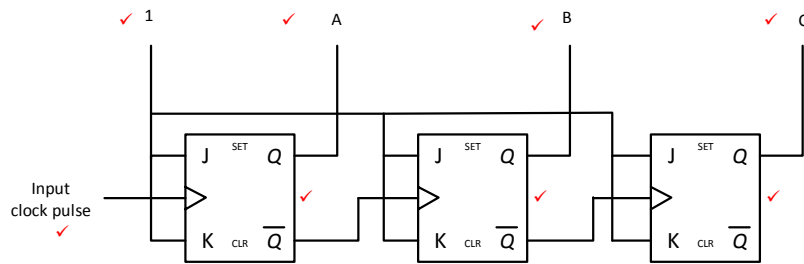
4.8 The TWO types of counters that are commonly used are:

Synchronous counters ✓

Asynchronous counters ✓

(2)

4.9 4.9.1



(8)

4.9 4.9.2

CLOCK PULSES ✓	BINARY COUNT SEQUENCE			DECIMAL COUNT ✓
	C	B	A	
0	1	1	1	7
1	1	1	0 ✓	6
2	1	0	1	5
3	1	0	0 ✓	4
4	0	1	1	3
5	0	1	0 ✓	2
6	0	0	1	1
7	0	0	0 ✓	0
8	1	1	1	7

1 mark for CLOCK PULSES column

1 mark for every 2nd BINARY COUNT SEQUENCE

1 mark for DECIMAL COUNT

(6)

4.10 Serial – in : Serial – out shift register (SISO) ✓

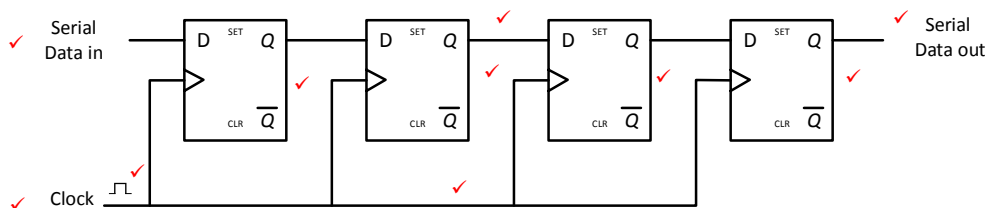
Serial – in : Parallel – out shift register (SIPO) ✓

Parallel – in : Serial – out shift Register (PISO) ✓

Parallel – in : Parallel – out shift Register (PIPO)

(3)

4.11



(10)

[55]



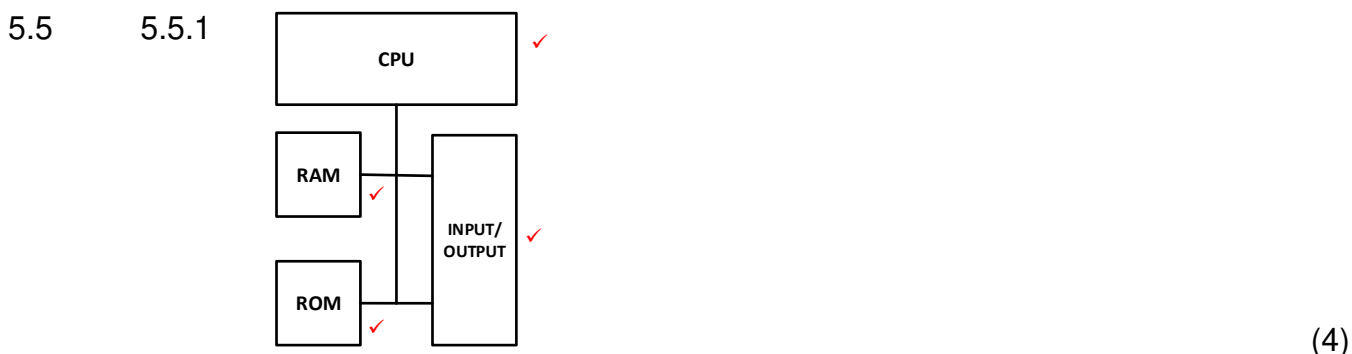
### QUESTION 5: MICROCONTROLLERS

5.1 Alarm monitoring and warning devices ✓  
Fire detection and safety devices ✓  
Temperature sensing and control  
Light sensing and control (2)

5.2 The main disadvantage of a microcontroller is that it has a very low output, of a few mA ✓ and this therefore requires interfacing circuitry ✓ to drive higher current loads. (2)

5.3 A microprocessor is an Integrated Circuit (IC) with only a Central Processing Unit (CPU). ✓  
A microcontroller is a complete, small scale computer ✓ with all the necessary devices required to function, embedded together on a single IC chip. ✓ (3)

5.4 Discreet logic consists of a number ✓ of separate logic chips interconnected. ✓  
Integrated logic is a single logic chip ✓ containing all the chips in one package. ✓ (4)



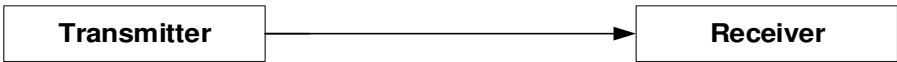
5.5.2 The function of the CPU is to interpret and execute ✓ the stored instructions from the Read Only Memory (ROM) programme. ✓ (2)

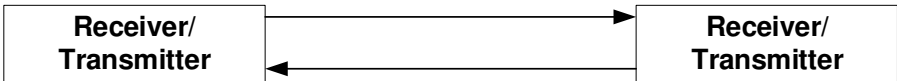
5.6 The Programme Counter (PC) ✓  
The Memory Address Register (MAR) ✓  
The Memory Data Register (MDR) ✓  
The Current Instruction Register (CIR) (3)

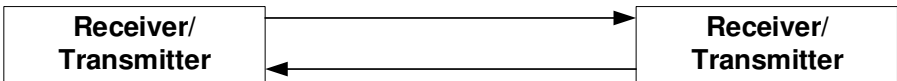
5.7 5.7.1 Clock speed refers to the number of pulses per second generated by an oscillator that sets the tempo for the processor. ✓ (1)

5.7.2 The higher the clock speed the faster ✓ the CPU will perform each instruction. (1)

5.8 The function of an ADC is to convert an analogue input signal ✓ into digital input ✓ as microcontrollers operate only on digital signals. (2)

5.9 5.9.1  (2)

5.9.2  (2)

5.9.3  (2)

5.10

	RS-232	RS-485
Line configuration	Single-ended ✓	Differential ✓
Maximum cable length	15 metres ✓	1200 metres ✓
Maximum data rate	20 kbits/second ✓	10 Mbits/second ✓
Typical logic levels	$\pm 5$ to $\pm 15V$ ✓	1.5 to 6V ✓
Mode of operation	Simplex or full duplex ✓	Simplex or half duplex ✓

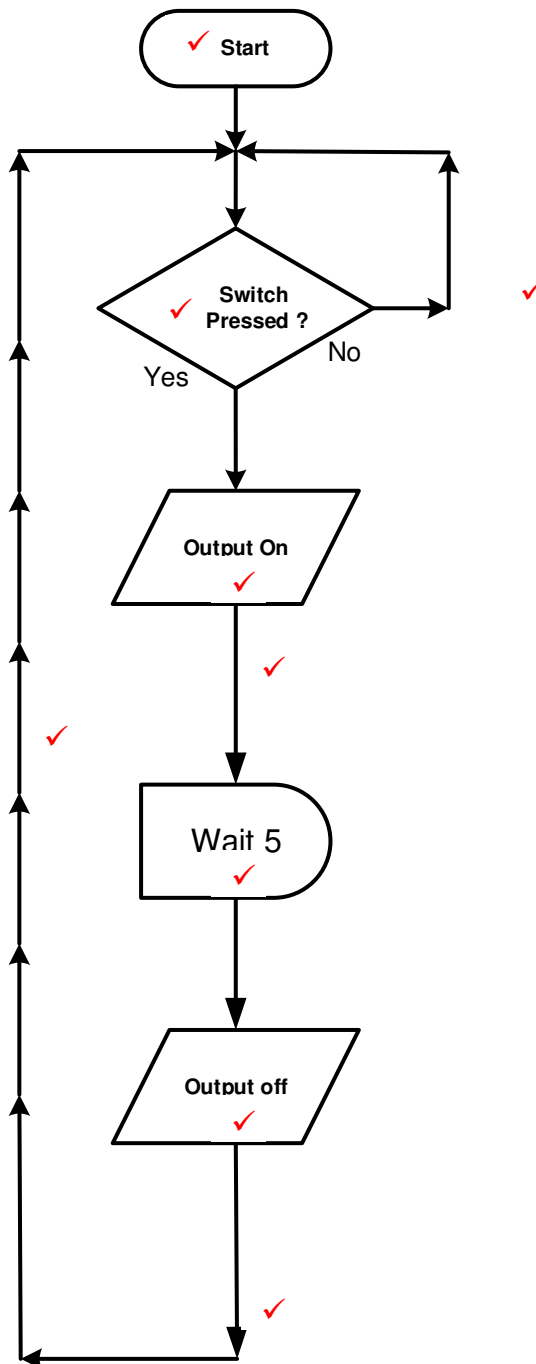
(10)

5.11.1 An algorithm is a detailed step-by-step sequence of instructions ✓ that are followed to complete a task. ✓ (2)

5.11.2 A program is a sequence of instructions ✓ that tells a computer how to execute a function. ✓ (2)

5.11.3 A flow diagram is a visual representation ✓ of the sequence of steps needed to perform and complete a process. ✓ (2)

5.12



(9)  
(55)

TOTAL: 200