

# GATE Petroleum Engineering (PE) 2024

## GENERAL APTITUDE (GA)

- 1) The fishermen, \_\_\_\_\_ the flood victims owed their lives, were rewarded by the government.
- whom
  - to which
  - to whom
  - that

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- 2) Some students were not involved in the strike. If the above statement is true, which of the following conclusions is/are logically necessary?
- Some who were involved in the strike were students.
  - No student was involved in the strike.
  - At least one student was involved in the strike.
  - Some who were not involved in the strike were students.
- a and b
  - c
  - d
  - b and c

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- 3) The radius as well as the height of a circular cone increases by 10%. The percentage increase in its volume is \_\_\_\_\_.
- 17.1
  - 21.0
  - 33.1
  - 72.8

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- 4) Five numbers 10, 7, 5, 4 and 2 are to be arranged in a sequence from left to right following the directions given below:
- No two odd or even numbers are next to each other.
  - The second number from the left is exactly half of the left-most number.
  - The middle number is exactly twice the right-most number.
- Which is the second number from the right?
- 2
  - 4
  - 7
  - 10

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- 5) Until Iran came along, India had never been \_\_\_\_\_ in kabaddi.
- defeated
  - defeating
  - defeat
  - defeatist

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- 6) Since the last one year, after a 125 basis point reduction in repo rate by the Reserve Bank of India, banking institutions have been making a demand to reduce interest rates on small saving schemes. Finally, the government announced yesterday a reduction in interest rates on small saving schemes to bring them on par with fixed deposit interest rates.

Which one of the following statements can be inferred from the given passage?

- a) Whenever the Reserve Bank of India reduces the repo rate, the interest rates on small saving schemes are also reduced
- b) Interest rates on small saving schemes are always maintained on par with fixed deposit interest rates
- c) The government sometimes takes into consideration the demands of banking institutions before reducing the interest rates on small saving schemes
- d) A reduction in interest rates on small saving schemes follow only after a reduction in repo rate by the Reserve Bank of India

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- 7) In a country of 1400 million population, 70% own mobile phones. Among the mobile phone owners, only 294 million access the Internet. Among these Internet users, only half buy goods from e-commerce portals. What is the percentage of these buyers in the country?

- a) 10.50
- b) 14.70
- c) 15.00
- d) 50.00

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- 8) The nomenclature of Hindustani music has changed over the centuries. Since the medieval period dhrupad styles were identified as baanis. Terms like gayaki and baaj were used to refer to vocal and instrumental styles, respectively. With the institutionalization of music education the term gharana became acceptable. Gharana originally referred to hereditary musicians from a particular lineage, including disciples and grand disciples.

Which one of the following pairings is NOT correct?

- a) dhrupad, baani
- b) gayaki, vocal
- c) baaj, institution
- d) gharana, lineage

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- 9) Two trains started at 7AM from the same point. The first train travelled north at a speed of 80 km/h and the second train travelled south at a speed of 100 km/h. The time at which they were 540 km apart is \_\_\_\_\_ AM.

- a) 9
- b) 10
- c) 11
- d) 11.30

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- 10) "I read somewhere that in ancient times the prestige of a kingdom depended upon the number of taxes that it was able to levy on its people. It was very much like the prestige of a head-hunter in his own community."

Based on the paragraph above, the prestige of a head-hunter depended upon

- a) the prestige of the kingdom
- b) the prestige of the heads
- c) the number of taxes he could levy
- d) the number of heads he could gather

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- 11) Match the following:

Here:

$\tau$ : shear stress

<i>P.</i> Bingham plastic	<i>I.</i> $\tau = \tau_y + \mu_p \dot{\gamma}$	(1)
<i>Q.</i> Power law	<i>II.</i> $\tau = k\dot{\gamma}^n$	
<i>R.</i> Power law with yield stress	<i>III.</i> $\tau = \tau_y + k\dot{\gamma}^n$	

TABLE I  
MATCHING OF RHEOLOGICAL MODELS WITH THEIR CONSTITUTIVE EQUATIONS

$\tau_y$ : yield value or yield stress  
 $\mu_p$ : shear viscosity  
 $n$ : power law index  
 $k$ : consistency index  
 $\dot{\gamma}$ : shear rate

- |                     |                     |
|---------------------|---------------------|
| a) P-II, Q-I, R-III | c) P-III, Q-II, R-I |
| b) P-I, Q-III, R-II | d) P-III, Q-I, R-II |

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12) Match the following for drill pipe failure:

<i>P.</i> Twist off	<i>I.</i> due to excessive torque	(2)
<i>Q.</i> Parting	<i>II.</i> due to excessive tension	
<i>R.</i> Collapse	<i>III.</i> due to extensive external pressure	
<i>S.</i> Fatigue	<i>IV.</i> due to cyclic loading	

TABLE II  
FAILURE MODES AND THEIR CAUSES

- |                               |                               |
|-------------------------------|-------------------------------|
| a) (A) P-III, Q-IV, R-I, S-II | c) (C) P-I, Q-II, R-III, S-IV |
| b) (B) P-II, Q-I, R-IV, S-III | d) (D) P-IV, Q-III, R-II, S-I |

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13) Which one of the following flow regimes is more favorable for gas lift operation?

- |                     |                        |
|---------------------|------------------------|
| a) (A) Bubbly flow  | c) (C) Churn flow      |
| b) (B) Annular flow | d) (D) Stratified flow |

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14) H<sub>2</sub>S gas is

- |                       |                          |
|-----------------------|--------------------------|
| a) (A) acidic.        | c) (C) lighter than air. |
| b) (B) non-corrosive. | d) (D) non-flammable.    |

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15) Which one of the following offshore platforms DOES NOT use buoyant columns or pontoons?

- |                              |                                   |
|------------------------------|-----------------------------------|
| a) (A) Tension leg platforms | c) (C) Spar platforms             |
| b) (B) Jack up platforms     | d) (D) Semi-submersible platforms |

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16) In which one of the following offshore platforms, the condition of the sea floor is a vital consideration?

- a) (A) Drill ship platforms
- b) (B) Tension leg platforms
- c) (C) Concrete gravity platforms

- d) (D) Floating, production, storage and offloading (FPSO) platforms

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17) The 'Klinkenberg effect' is related to

- a) (A) viscous fingering during water flooding in oil reservoirs.
- b) (B) hysteresis effect in relative permeability during drainage and imbibition process.
- c) (C) oil viscosity dependence on temperature.
- d) (D) slippage of gas ph

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18) Favorable conditions for formation of gas hydrates are

- a) (A) high temperature and high pressure.
- b) (B) high temperature and low pressure.
- c) (C) low temperature and high pressure.
- d) (D) low temperature and low pressure.

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19) Match the following quantities with their dimensions:

<i>P.</i> Viscosity	<i>I.</i> $M^1L^{-1}T^{-1}$
<i>Q.</i> Permeability	<i>II.</i> $M^0L^2T^0$
<i>R.</i> Compressibility	<i>III.</i> $M^{-1}L^1T^2$
<i>S.</i> Pressure	<i>IV.</i> $M^1L^{-1}T^{-2}$

TABLE III  
PHYSICAL QUANTITIES WITH THEIR DIMENSIONAL FORMULAS

- a) (A) P-III, Q-II, R-IV, S-I
- b) (B) P-II, Q-I, R-IV, S-III
- c) (C) P-III, Q-I, R-IV, S-II
- d) (D) P-I, Q-II, R-III, S-IV

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20) The plot of dissolved gas oil ratio ( $R_s$ ), defined as the "ratio of STP volume of gas dissolved in the oil at pressure P, to the volume of the oil at STP" is given below.

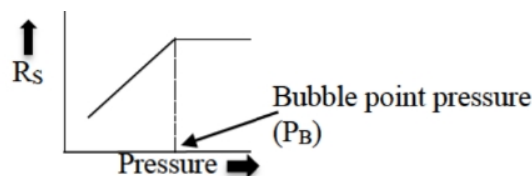


Fig. 1.

[Insert Figure: Plot of  $R_s$  vs Pressure with Bubble point pressure marked]

For the same oil, the plot of produced gas oil ratio ( $R_p$ ) defined as the "ratio of STP volume of the gas liberated from the oil at pressure P, to the volume of the oil at STP" is

- a) (A) [Figure A]
- b) (B) [Figure B]
- c) (C) [Figure C]
- d) (D) [Figure D]

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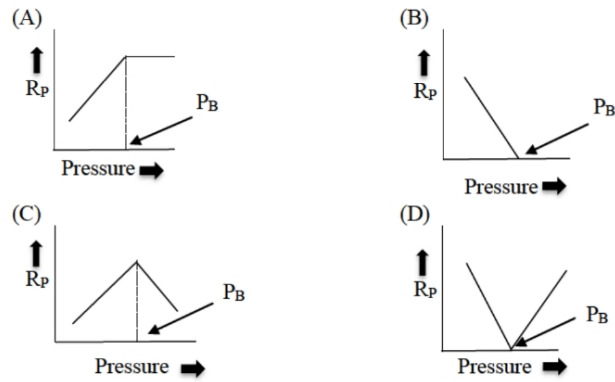


Fig. 2.

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21) Which one of the following denotes a regular four-spot flood pattern?

A represents injection well  
o represents production well

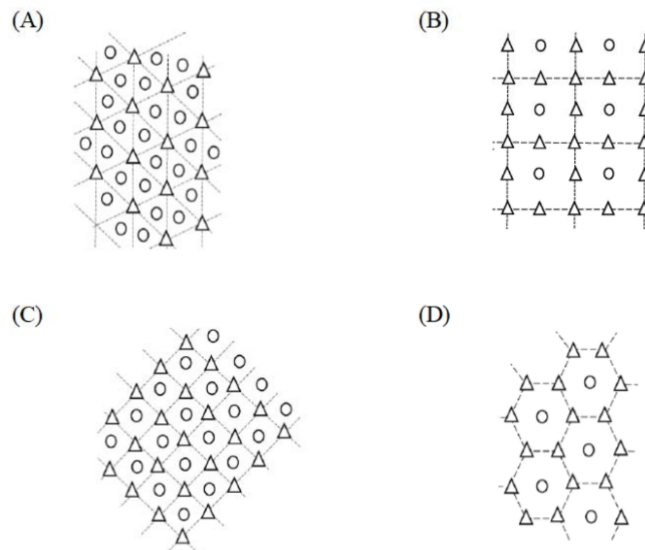


Fig. 3.

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22) The value of  $\lim_{x \rightarrow 0} \frac{(x+1)\sin x}{x^2+2x}$  is (round off to 2 decimal places).  
Numerical answer

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23) Let  $A = \begin{pmatrix} 1 & 2 \\ 2 & 1 \end{pmatrix}$ ,  $X = \begin{pmatrix} 1 & a \\ b & 0 \end{pmatrix}$  and  $Y = \begin{pmatrix} 3 & 1 \\ 3 & 2 \end{pmatrix}$ . If  $AX = Y$ , then  $a + b$  equals .  
Numerical answer

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24) Let  $\mathbf{u} = \hat{i} + \hat{j} + a\hat{k}$  and  $\mathbf{v} = a^2\hat{i} + 4\hat{j} - 4\hat{k}$ , where  $\hat{i}$ ,  $\hat{j}$  and  $\hat{k}$  are cartesian unit vectors. If  $\mathbf{u}$  is perpendicular to  $\mathbf{v}$ , then  $a$  equals



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- 29) The fractional flow ( $f_w$ ) versus water saturation ( $S_w$ ) curve for an imbibition process (neglecting the capillary forces) in a given core for three different inclinations is shown in the figure.

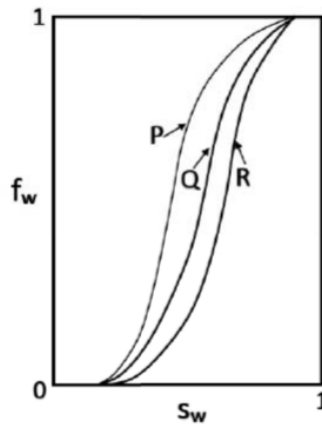


Fig. 5.

Which one of the following is the correct representation of the fractional flow curves?

- a) (A) P: Down-dip, Q: No-dip, R: Up-dip      c) (C) P: No-dip, Q: Down-dip, R: Up-dip  
b) (B) P: Down-dip, Q: Up-dip, R: No-dip      d) (D) P: Up-dip, Q: No-dip, R: Down-dip

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- 30) Match the following:

P. Dynamic positioning	I. System for automatic position control
Q. Mooring	II. Station keeping system
R. Jack-up	III. Self-contained drilling rig on a floating barge
S. Semi-submersible platform	IV. Weight and buoyancy balance

TABLE IV  
MATCHING OFFSHORE DRILLING SYSTEMS WITH THEIR DESCRIPTIONS

- a) (A) P-IV, Q-II, R-I, S-III      c) (C) P-II, Q-IV, R-I, S-III  
b) (B) P-III, Q-I, R-IV, S-II      d) (D) P-II, Q-IV, R-III, S-I

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- 31) Match the following:

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- 32) An exploratory well encountered three reservoir formations S1 (perfectly cemented), S2 (poorly cemented) and S3 (fractured). The Formation Factor ( $F$ ) is governed by the equation  $F = \alpha \phi^{-m}$ , where ' $\phi$ ' is the porosity and ' $m$ ' is the cementation factor. The constant ' $\alpha$ ', linked to tortuosity is assumed to be 1 for all formations. The log-log plot between Formation Factor ( $F$ ) and porosity ( $\phi$ ) is shown.

Which one of the following represents the correct match of the formations with their respective plots?

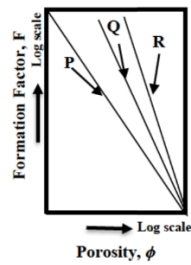


Fig. 6.

- a) (A) S1-P, S2-Q, S3-R  
 b) (B) S1-R, S2-P, S3-Q  
 c) (C) S1-P, S2-R, S3-Q  
 d) (D) S1-R, S2-Q, S3-P

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- 33) Typical parameters obtained in the pyrolysis experiment of the source rock materials are shown in the Figure. Which one of the following is NOT true about pyrolysis in source rock analysis?

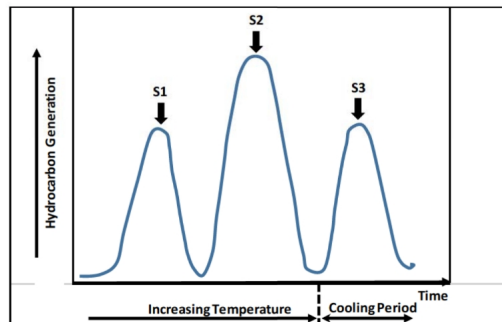


Fig. 7.

- a) (A) Peak S1 represents volatilization of existing hydrocarbons  
 b) (B) Peak S2 represents breakdown of kerogen and generation of hydrocarbons  
 c) (C) Peak S3 represents  $T_{\max}$ , the temperature at which most hydrocarbons are generated  
 d) (D)  $S1/(S1+S2)$  represents the production index

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- 34) A single well encounters multiple clean sands of exactly the same thickness, porosity and permeability.  $R_w$  is the formation fluid resistivity and  $R_{mf}$  is the mud filtrate resistivity.

$$\begin{aligned}
 P. R_{mf} &> R_w & I. \text{ No deflection} \\
 Q. R_{mf} &= R_w & II. \text{ Positive deflection} \\
 R. R_{mf} &< R_w & III. \text{ Negative deflection}
 \end{aligned}
 \tag{6}$$

Which one of the following matches the relation between  $R_w$  and  $R_{mf}$  to that of Self Potential (SP) log deflection?

- a) (A) P-I, Q-III, R-II  
 b) (B) P-III, Q-I, R-II  
 c) (C) P-II, Q-I, R-III  
 d) (D) P-I, Q-II, R-III

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- 35) Which one of the following options is NOT a part of the mudlogs prepared by the drill-site geologist?



- a) (A) Rate of Penetration (ROP)
- b) (B) Chromatograph showing presence of  $C_1$  to  $C_5$  concentration
- c) (C) Lithology from drill cutting and its interpretation
- d) (D) Reservoir unit delineation based on volume of shale ( $V_{sh}$ )

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Q.36 Match the following:

- |   |                |     |
|---|----------------|-----|
| P. Location of storing the kelly on the trip                      | I. Mousehole   | (7) |
| Q. Location of storing the next drill pipe                        | II. Rathole    |     |
| R. Location of storing pump pressure gauges                       | III. Top drive |     |
| S. Rotational system that controls a drill string without a kelly | IV. Standpipe  |     |

TABLE V  
DRILLING EQUIPMENT AND THEIR LOCATIONS/FUNCTIONS

- |                               |                               |
|-------------------------------|-------------------------------|
| a) (A) P-II, Q-I, R-IV, S-III | c) (C) P-II, Q-I, R-III, S-IV |
| b) (B) P-IV, Q-II, R-III, S-I | d) (D) P-IV, Q-III, R-II, S-I |

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- 36) A box contains 2 red and 3 black balls. Three balls are randomly chosen from the box and are placed in a bag. Then the probability that there are 1 red and 2 black balls in the bag, is .

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- 37) The values of a function  $f(x)$  over the interval  $[0,4]$  are given in the table below:

$x$	0	1	2	3	4
$f(x)$	1	0.5	0.2	0.1	0.06

(8)

TABLE VI  
VALUES OF  $f(x)$  FOR GIVEN  $x$

Then, according to the trapezoidal rule, the value of the integral  $\int_0^4 f(x)dx$  is (round off to 2 decimal places).

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- 38) Oil is produced at a constant rate from a well in a bounded reservoir. The variation of the bottom-hole pressure with time is shown in the given Table. The magnitude of the slope of the pressure vs time curve that you would use to find the drainage area is psi/day (round off to 1 decimal place).

Time (days)	Pressure (psi)	Time (days)	Pressure (psi)
0	3500	6	2512
1	2864	7	2482
2	2725	8	2452
3	2644	9	2422
4	2587	10	2392
5	2542	11	2362

TABLE VII  
PRESSURE DECLINE DATA OVER TIME

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- 39) In a core flood experiment of immiscible and incompressible displacement of oil ( $\mu_o = 1$  cP) with water ( $\mu_w = 1$  cP), only axial flow is observed. The relative permeability of water is given by  $k_{rw} = S_w^2$ ,

where  $S_w$  is water saturation. The relative permeability of oil is given by  $k_{ro} = (1 - S_w)^2$ . The gravity and capillary pressure are neglected. From the fractional flow and water saturation relationship, the saturation of water at the flood front is \_\_\_\_\_ % (round off to 1 decimal place).

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- 40) In an oil well, the pressure at the gas oil contact (GOC) at a depth of 2000 m is 205 bar (gauge), as shown in the figure.

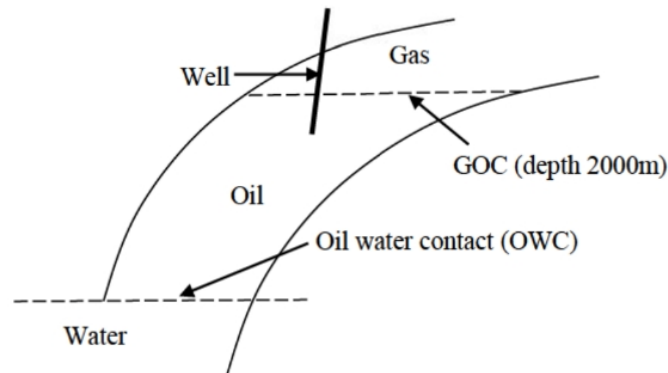


Fig. 8.

The static oil pressure gradient is 0.08 bar/m in the pay zone. If a constant hydrostatic pressure gradient of 0.1 bar/m prevails throughout the subsurface, then the thickness of the oil column is:

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- 41) Oil is produced at a constant rate of  $10 \text{ m}^3/\text{day}$  from a reservoir for 500 days. The producing gas oil ratio (GOR) is constant at  $10 \text{ m}^3_{\text{gas}}/\text{m}^3_{\text{oil}}$  for the first 100 days. Then, the producing gas oil ratio increases linearly and on the 500<sup>th</sup> day the measured GOR is  $50 \text{ m}^3_{\text{gas}}/\text{m}^3_{\text{oil}}$ . The cumulative produced gas oil ratio after 500 days of production is

$\text{m}^3_{\text{gas}}/\text{m}^3_{\text{oil}}$  (round off to 1 decimal place). Assume that all volumes are measured at STP.

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- 42) A pressure build-up test was conducted in a well after 1000 days of producing oil at a constant rate of  $0.01 \text{ reservoir-m}^3/\text{s}$ . The two shut-in bottom-hole pressure readings taken at 0.5 day and 1 day after shut-in are  $150 \times 10^5 \text{ Pa}$  and  $151 \times 10^5 \text{ Pa}$ , respectively. These pressure points correspond to the linear region of the Horner's plot. The reservoir thickness is 100 m and oil viscosity is  $0.001 \text{ Pa.s}$ . The permeability of the reservoir is

mD (round off to 1 decimal place). [ $1 \text{ mD} = 10^{-15} \text{ m}^2$ ]

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- 43) In an oil reservoir, the residual oil saturation in the volume flooded with polymer solution is 20%. The initial water saturation is 20%. The volumetric sweep efficiency is 50%. The maximum possible recovery factor for the reservoir is \_\_\_\_\_ % (round off to 1 decimal place).

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- 44) An electrical submersible pump (ESP) delivers well fluid with 100% watercut. In the ESP, the impeller diameter is 0.1 m and speed is 3600 rpm. The total head developed by the ESP is 300 m (water column height). If the stage efficiency of the ESP is 60%, then the minimum number of stages required is

(round off to nearest integer). [ $g = 9.81 \text{ m/s}^2$ ]

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- 45) In a counter flow heat exchanger, hot fluid enters at  $100^{\circ}\text{C}$  and leaves at  $50^{\circ}\text{C}$ . Cold fluid enters at  $30^{\circ}\text{C}$  and leaves at  $40^{\circ}\text{C}$ . If heat losses are ignored, then the logarithmic mean temperature difference (LMTD) is  $^{\circ}\text{C}$  (round off to 1 decimal place).

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- 46) A model porous block of cross-sectional area ( $A$ ) and length ( $L$ ) is made up of  $N$  independent capillaries of equal radii ( $r$ ) and length ( $L$ ). The porosity of the block is 10%, and the permeability for a laminar, incompressible and steady state flow is 0.02 mD. If the flow is only through the capillaries, then the value of  $r$  is  $\text{---} \times 10^{-6} \text{ cm}$  (round off to 1 decimal place). [1 mD =  $10^{-15} \text{ m}^2$ ]

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- 47) A model porous medium of 5 cylindrical capillaries of radii varying from 60 to  $100 \mu\text{m}$  is subjected to Mercury Injection Capillary Pressure (MICP) treatment. The capillaries are being filled in an increasing order of their entry pressure. The magnitude of  $(\sigma \cos \theta)_{\text{air-Hg}}$  is 367 dyne/cm, where  $\sigma$  is the interfacial tension and  $\theta$  is the contact angle. The minimum applied mercury pressure to achieve 50% mercury saturation in the sample is  $\text{---} \times 10^3 \text{ dyne/cm}^2$  (round off to 1 decimal place).

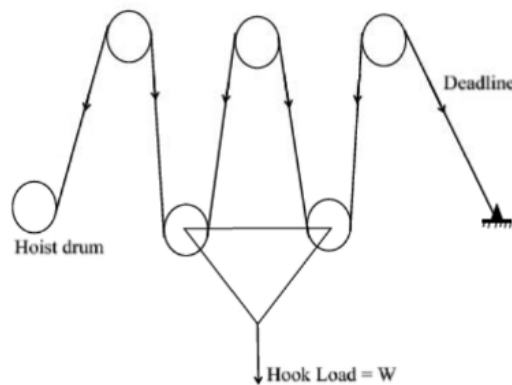


Fig. 9.

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- 48) The sonic log parameters from an exploratory well in a reservoir are as follows:  
 Measured P-wave transit time ( $\Delta t_{\log}$ ) =  $85 \mu\text{s/ft}$  True resistivity ( $R_t$ ) =  $10 \Omega\text{-m}$  Matrix transit time ( $\Delta t_{\text{mat}}$ ) =  $45 \mu\text{s/ft}$  Fluid transit time ( $\Delta t_{fl}$ ) =  $205 \mu\text{s/ft}$  Formation water resistivity at reservoir temperature ( $R_w$ ) =  $0.1 \Omega\text{-m}$   
 The hydrocarbon saturation (in percentage) in the reservoir is

(round off to 1 decimal place).

[Hint: Wyllie time average equation is  $\Delta t_{\log} = (1 - \phi)\Delta t_{\text{mat}} + \phi\Delta t_{fl}$  and formation water resistivity has the correlation  $R_w = \frac{a}{\phi^m} R_t S_w^n$ , where  $S_w$  is water saturation,  $\phi$  is porosity and  $a = 1$ ]

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- 49) A vertical well of 8000 ft is producing below bubble point pressure. Oil and water each is produced at the rate of 500 bbl/day. The indicated bottom hole pressure is 3000 psia. If the same gas to liquid ratio (GLR) is maintained, using the given figure, the new bottom hole pressure at 5000 ft is  $\text{---}$  psi.

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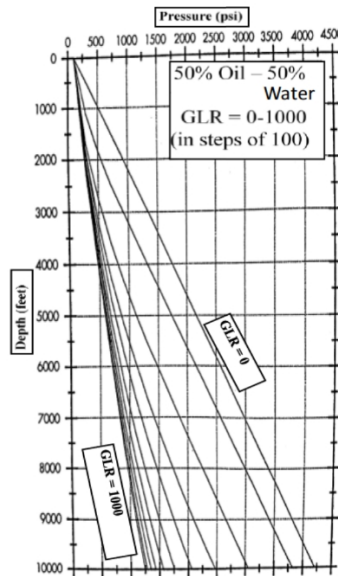


Fig. 10.

- 50) In a drilling rig, the crown block and the traveling block have three and two sheaves, respectively. A single wireline connects the hoisting drum to the deadline anchor as shown in the figure. Neglect the weight of the pulleys and the wireline, and friction between the sheaves and wireline. The ratio of the deadline load to static crown load is (round off to 2 decimal places).

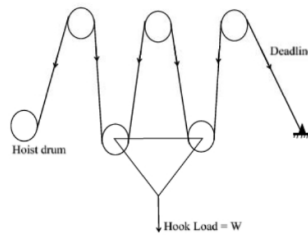


Fig. 11.

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- 51) Cement weighing 100kg is mixed with 50 liters of water. The specific gravity of cement is 3.14 and the density of water is  $1000\text{kg/m}^3$ . Neglecting volume changes, the resulting density of the slurry is

$\text{kg/m}^3$  (round off to 1 decimal place).

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- 52) In an active water drive during a certain period, the rate of production and reservoir pressure remain constant. The water influx into the reservoir from the aquifer is 6000 bbl/day. The surface oil and water production rates are 3000 STB/day and 1500 STB/day, respectively. The current production gas to oil ratio is 825 SCF/STB, and the formation volume factors at the current pressure for oil, water, and gas are 1.375 bbl/STB, 1.04 bbl/STB, and 0.007 bbl/STB, respectively. The solution gas to oil ratio at the current pressure is

SCF/STB (round off to 1 decimal place).

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- 53) In a water flooding experiment, the pressure gradients in the displacing and displaced phases are 400 psi/ft and 350 psi/ft, respectively. Assume that the displacement front is stable in the absence of capillary and gravity forces. Consider that only water flows upstream and only oil flows downstream of the displacement front. Then, the mobility ratio for this immiscible displacement process is

(round off to 2 decimal places).

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- 54) In a pressure draw-down testing, the well bore flowing pressure ( $P_{wf}$ ) is given by

$$P_{wf} = P_i - \frac{162.6 q \mu B}{k h} \left[ \log \left( \frac{k t}{\phi \mu c_t r_w^2} \right) - 3.23 + 0.87 S \right] \quad (9)$$

The following data is given in the oil field units:

Initial reservoir pressure ( $P_i$ ) = 5000 psia Pressure after 1 hr of production ( $P_{1hr}$ ) = 4000 psia Oil flow rate ( $q$ ) = 500 STB/day Porosity ( $\phi$ ) = 0.25 Viscosity of oil ( $\mu$ ) = 2 cP Formation volume factor of oil ( $B$ ) = 1.2 bbl/STB Formation thickness ( $h$ ) = 20 ft Total compressibility ( $c_t$ ) =  $30 \times 10^{-6}$  psi<sup>-1</sup> Well bore radius ( $r_w$ ) = 0.3 ft

The slope of  $P_{wf}$  versus  $\log t$  is -100 psi/cycle. Then, the skin factor ( $S$ ) for this well is

(round off to 1 decimal place).

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— END OF THE QUESTION PAPER —