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FREE APP CLASS SCHEDULE

MECHANICAL ENGINEERING

GATE

HMT	MONDAY Live @11AM	YOGESH SIR
PRODUCTION	TUESDAY Live @11AM	GAURAV SIR
SOM	WEDNESDAY Live @8PM	MUKESH SIR
THERMODYNAMICS	THURSDAY Live @11AM	KANISTH SIR
ENGINEERING MATHEMATICS	FRIDAY Live @11AM	ANANT SIR

ISRO | BHEL | DRDO & OTHER PSUs

GATE

Thermodynamics

Second Law

MOST EXPECTED QUESTIONS

Live@ 3pm

PART-2

Kanisth sir

A reversible Carnot engine operates between 27°C and 1527°C, and produces 400 kW of net power. The change of entropy of the working fluid during the heat addition process is

(a) 0.222 kW/K

(b) 0.266 kW/K

(c) 0.288 kW/K

(d) 0.299 kW/K

[ESE : 2018]

Which of the following devices complies with the Clausius statement of the second law of thermodynamics?

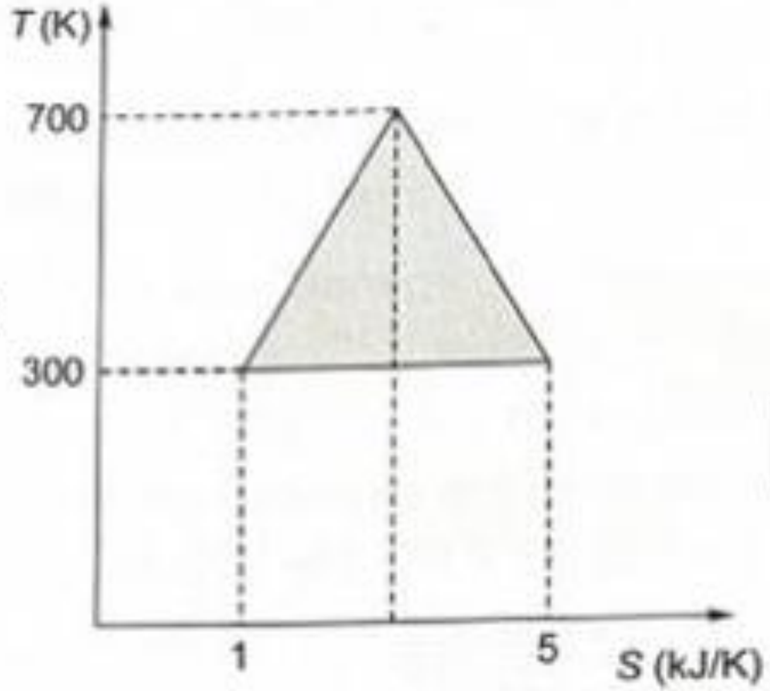
(a) Closed-cycle gas turbine

(b) Internal combustion engine

(c) Steam power plant

(d) Domestic refrigerator [ESE : 2018]

The thermal efficiency of the hypothetical cycle shown is



(a) 0.6
(b) 0.5
(c) 0.4
(d) 0.3

[ESE : 2017]

Two reversible engines are connected in series between a heat source and a sink. The efficiencies of these engines are 60% and 50%, respectively. If these two engines are replaced by a single reversible engine, the efficiency of this engine will be

(a) 60% (b) 70%

(c) 80% (d) 90%

[ESE : 2018]

Consider the following statements:

1. Entropy is related to the first law of thermodynamics.
2. The internal energy of an ideal gas is a function of temperature and pressure.
3. The zeroth law of thermodynamics is the basis for measurement of temperature.

Which of the above statements are correct?

(a) 1 and 2 only (b) 1 and 3 only

(c) 2 and 3 only (d) 1, 2 and 3

[ESE : 2018]

A heat engine receives heat at the rate of 2500 kJ/min and gives an output of 12.4 kW. Its thermal efficiency is, nearly :

(a) 18%
(b) 23%
(c) 26%
(d) 30%

[ESE : 2016]

One reversible heat engine operates between 1000 K and T_2 K. and another reversible heat engine operates between T_2 K and 400 K. If both the engines have the same heat input and output, then the temperature T_2 must be equal to :

(a) 582.7 K
(b) 632.5 K
(c) 682.8 K
(d) 732.5 K

[ESE : 2016]

A system of 100 kg mass undergoes a process in which its specific entropy increases from 0.3 kJ/kg K to 0.4 kJ/kg K. At the same time, the entropy of the surroundings decreases from 80 kJ/K to 75 kJ/K. The process is :

(a) Reversible and isothermal

(b) Irreversible

(c) Reversible only

(d) Isothermal only

[ESE : 2016]

A Carnot engine operates between 300 K and 600 K. If the entropy change during heat addition is 1 kJ/K, the work produced by the engine is:

(a) 100 kJ (b) 200 kJ

(c) 300 kJ (d) 400 kJ

[ESE : 2016]

Which of the following statements pertaining to entropy are correct ?

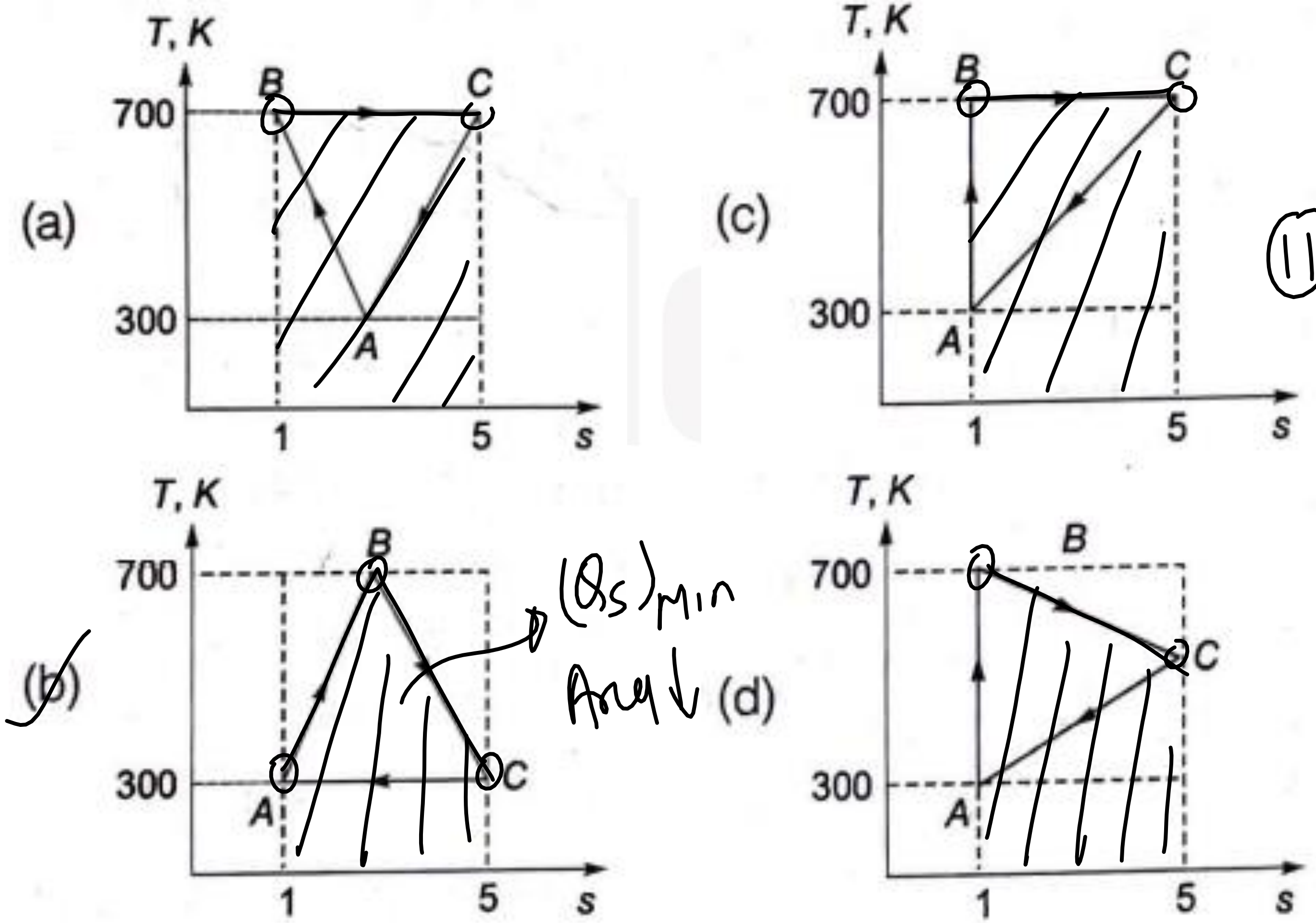
1. The entropy of a system reaches its minimum value when it is in a state of equilibrium with its surroundings
2. Entropy is conserved in all reversible processes
3. Entropy of a substance is least in solid phase
4. Entropy of a solid solution is not zero at absolute zero temperature

(a) 1, 2 and 3 only (b) 2, 3 and 4 only

(c) 3 and 4 only (d) 1, 2, 3 and 4

[ESE : 2016]

Q. Which one of the following hypothetical heat engine cycle represents maximum efficiency? {[CSE-Pre : 1999]}



$\eta = \frac{W_{net}}{Q_s}$ → SAME

$Q_s \to (Q_s)_{min} \Rightarrow \eta_{max}$

(1) → (b)

Q = Area UNDER T-S DIAGRAM

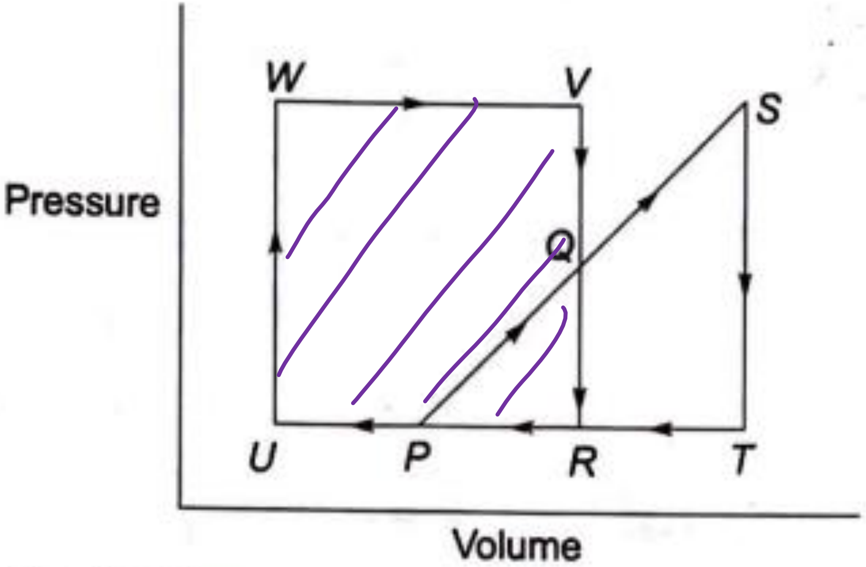
$= \int_1^2 T\,ds$

ds → '+'ve ⇒ Q_s

ds → '−'ve ⇒ Q_R

12 → (c)

Two ideal heat engine cycles are represented in the given figure. Assume *VQ* = *QR*, *PQ* = *QS* and *UP* = *PR* = *RT*. If the work interaction for the rectangular cycle (WVUR) is 48 Nm, then the work interaction for the other cycle *PST* is



(a) 12 N m
(b) 18 Nm
(c) 24 N m ✓
(d) 36 Nm

[CSE-Pre : 2001]

$UR \times VR = 48$

$(2PR)(2QR) = 48$

ΔPST

$\frac{1}{2} PT \times ST$

$\frac{1}{2}(2PR) \times (2QR)$

$\Rightarrow \frac{48}{2} \Rightarrow 24$ Nm

$\Delta PQR \sim \Delta PST$

$\frac{PR}{PT} = \frac{QR}{ST}$

$ST = \frac{QR \times (2PR)}{PR}$

$ST = 2QR$

Two reversible engines are working in series between a high temperature reservoir at 1000 K and a low temperature reservoir at 300 K in such a way that the heat rejected by the preceding engine is completely absorbed by the succeeding engine and both the engines develop the same amount of work per cycle. What is the intermediate temperature between first and second engines?

(a) 700 K

(b) 650 K ✓

(c) 350 K

(d) Not possible to be estimated with the given data

(13)

$W_1 = W_2$

$T_2 = \frac{T_1 + T_3}{2}$

$= \frac{1000 + 300}{2}$

$= 650\ K$

$\eta_1 = \eta_2$

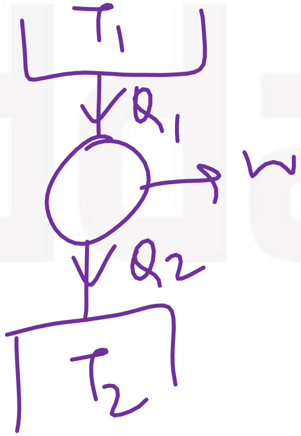
$T_2 = \sqrt{T_1 T_3}$

The thermal efficiency of the Carnot engine is 0.5. If the engine is operated as refrigerator, what is the C.O.P. of the refrigerator?

(a) 0.5 (b) 1.0

(c) 2.0 (d) 2.5

14 → b



$1 - \frac{T_2}{T_1} = 0.5$

$\frac{T_2}{T_1} = 0.5$

$\frac{T_1}{T_2} = \frac{1}{0.5} = 2$

$COP_{REF} = \frac{T_2}{T_1 - T_2}$

$= \frac{1}{\frac{T_1}{T_2} - 1}$

$= 1$

15 → (C)

For a Carnot engine $T_1 > T_2$. When T_2 is decreased by ΔT with T_1 remaining same then efficiency is η_1, and when T_1 is increased by ΔT with T_2 remaining same, efficiency is η_2. Which one of the following is the correct expression for $(\eta_1 - \eta_2)$?

(a) $\dfrac{(T_2 - T_1)\Delta T + (\Delta T)^2}{T_2(T_2 + \Delta T)}$

(b) $\dfrac{(T_2 - T_1)\Delta T + (\Delta T)^2}{T_1(T_1 + \Delta T)}$

(c) $\dfrac{(T_1 - T_2)\Delta T + (\Delta T)^2}{T_1(T_1 + \Delta T)}$ ✓

(d) $\dfrac{(T_1 + T_2)\Delta T + (\Delta T)^2}{T_1(T_1 + \Delta T)}$

$$\eta_1 = 1 - \frac{T_2 - \Delta T}{T_1} \quad \text{—(i)}$$

$$\eta_2 = 1 - \frac{T_2}{T_1 + \Delta T} \quad \text{—(ii)}$$

$$\eta_1 - \eta_2 = 1 - \frac{T_2 - \Delta T}{T_1} - 1 + \frac{T_2}{T_1 + \Delta T}$$

$$= \frac{(\Delta T - T_2)(T_1 + \Delta T) + T_2 T_1}{T_1(T_1 + \Delta T)}$$

$$= \frac{\Delta T\, T_1 + \Delta T^2 - T_1 T_2 - T_2 \Delta T + T_2 T_1}{T_1(T_1 + \Delta T)}$$

$$= \frac{(T_1 - T_2)\Delta T + \Delta T^2}{T_1(T_1 + \Delta T)}$$

16

Assertion (A): Two engines *A* and *B* work on the Carnot cycle. Engine *A* uses air as the working substance and *B* uses steam as the working substance. Both engines are having same efficiency.

Reason (R): Carnot cycle efficiency is independent of working substance.

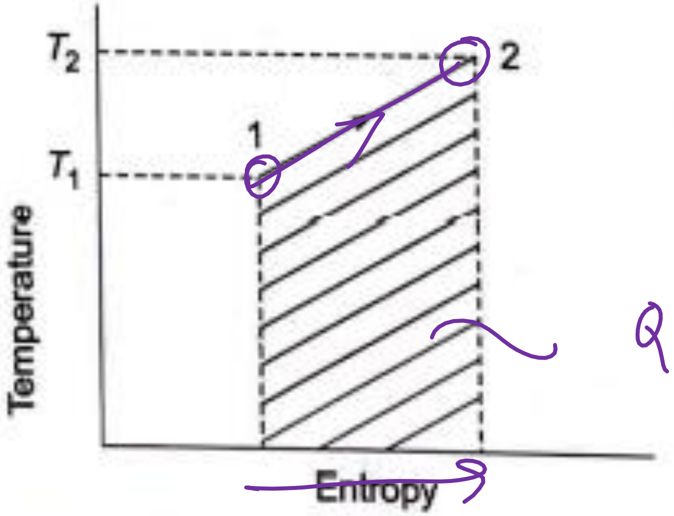
(a) Both A and R are true and R is a correct explanation of A.

(b) Both A and R are true but R is not a correct explanation of A.

(c) A is true but R is false.

(d) A is false but R is true.

[CSE-Pre : 2007]



In the T-S diagram shown in the figure, which one of the following is represented by the area under the curve ?

(a) Total work done during the process

(b) Total heat absorbed during the process

(c) Total heat rejected during the process

(d) Degree of irreversibility

[CSE-Pre : 2004]

17 → b

Q = HEAT TRANSFER = $\int_1^2 T\,ds$

T → ABSOLUTE

ds → +ve

Sys

Q_{ADDED} → +ve

A reversible heat transfer demands

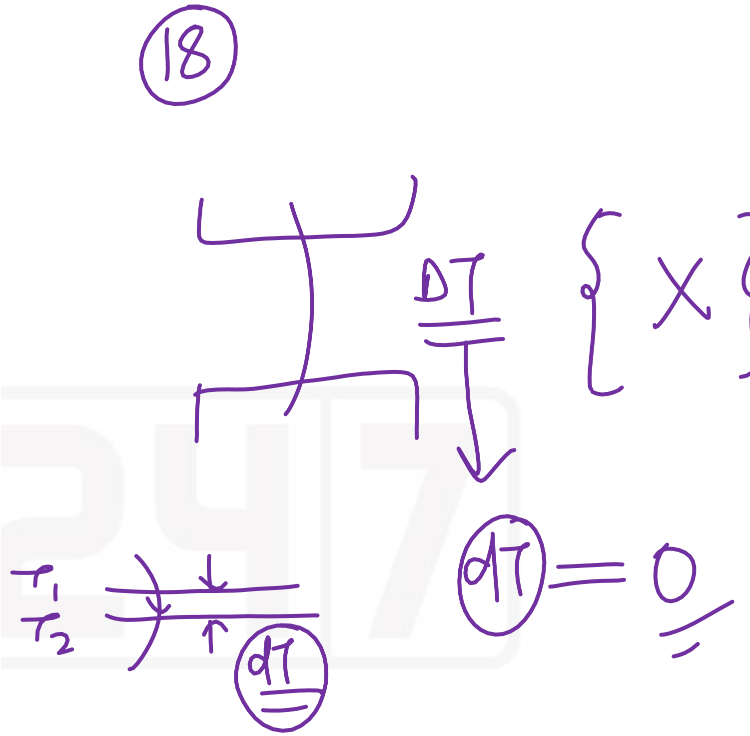
[1 Mark]

(A) The temperature difference causing heat transfer tends to zero

(B) The system receiving heat must be at a constant temperature.

(C) The system transferring out heat must be at a constant temperature.

(D) Both interacting systems must be at constant temperatures



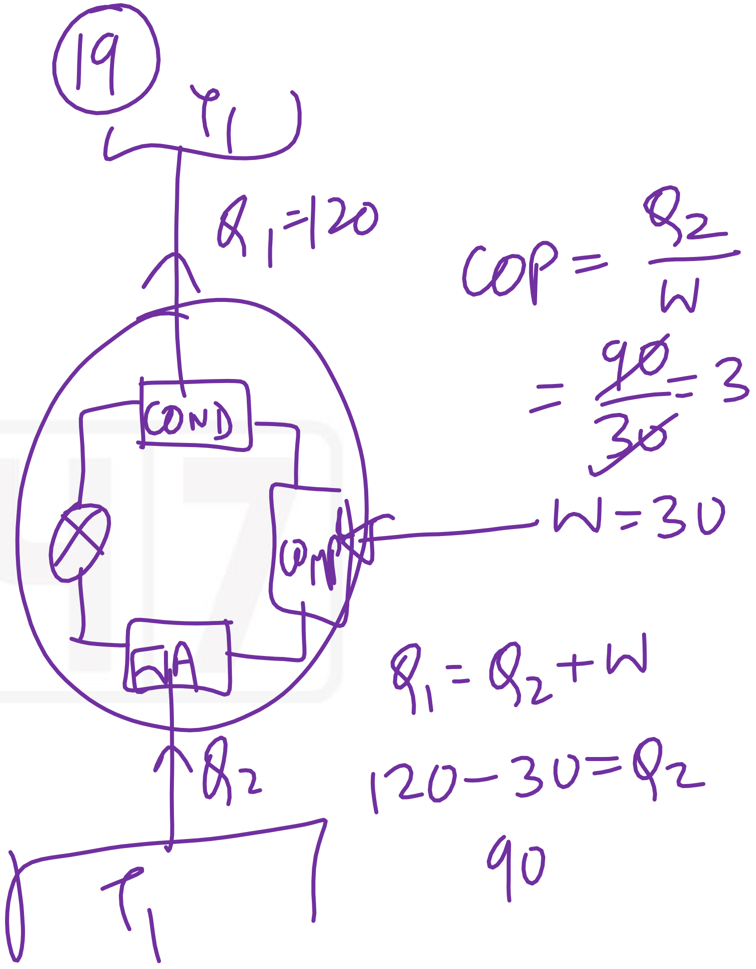
A condenser of a refrigeration system rejects heat at a rate of 120 kW, while its compressor consumes a power of 30 kW. The coefficient of performance of the system would be **[1 Mark]**

(A) $\frac{1}{4}$

(B) 4

(C) $\frac{1}{3}$

(D) 3



Any thermodynamic cycle operating between two temperature limits is reversible if the product of the efficiency when operating as a heat engine and the COP when operating as a refrigerator is equal to 1. **[1 Mark]**

For two cycles coupled in series, the topping cycle has an efficiency of 30% and the bottoming cycle has an efficiency of 20 %. The overall combined cycle efficiency is **[2 Marks]**

(A) 50% (B) 44%

(C) 38% (D) 55%

An irreversible heat engine extracts heat from a high temperature source at a rate of 100 kW and rejects heat to a sink at a rate of 50 kW. The entire work output of the heat engine is used to drive a reversible heat pump operating between a set of independent isothermal heat reservoirs at $17^{0}C$ and $75^{0}C$. The rate (in kW) at which the heat pump delivers heat to its high temperature sink is

[2 Marks]

(A) 50 (B) 250

(C) 300 (D) 360

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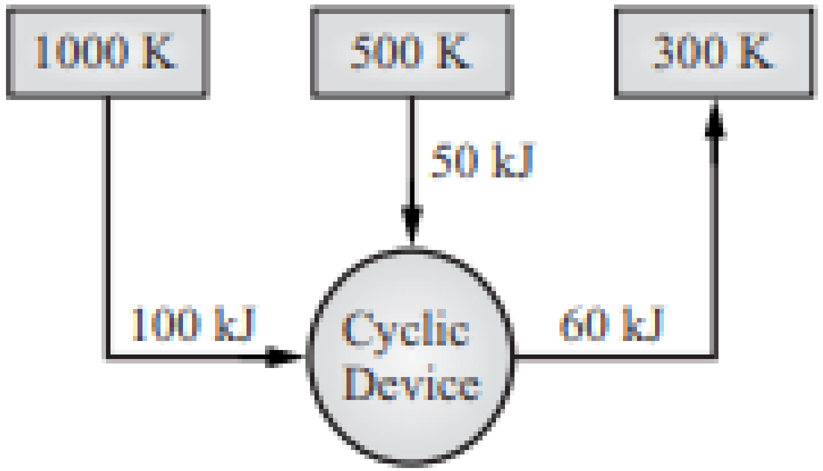
Q. A cyclic device operates between three thermal reservoirs, as shown in the figure. Heat is transferred to/from the cycle device. It is assumed that heat transfer between each thermal reservoir and the cyclic device takes place across negligible temperature difference. Interactions between the cyclic device and the respective thermal reservoirs that are shown in the figure are all in the form of heat transfer. [2 Marks]



APP → 11 AM → 3 HRS → CONCEPTS → ZERO LEVEL

FRI / SAT / SUN (OFF)

*** MONDAY

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