KUMARAGURU
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B.E DEGREE EXAMINATIONS: MAY 2018

(Regulation 2015)

Sixth Semester

AERONAUTICAL ENGINEERING

U15AET604: Rocket Propulsion

COURSE OUTCOMES

CO1: Gain basic knowledge on rocket systems and subsystems
CO2: Gain basic design knowledge on solid rockets
CO3: Gain basic design knowledge on liquid rockets
CO4: Gain basic knowledge on rocket igniters and injectors
CO5: Developing creative thinking for advanced propulsion systems

Time: Three Hours   **Maximum Marks: 100**

Answer all the Questions:-
PART A (10 x 1 = 10 Marks)

1.   CO1 [K₂]

List I	List II
A. Solid Rocket	i. Solid Fuel and Liquid Oxidizer
B. Cryogenic Rocket	ii. Monopropellant
C. Satellite thruster	iii. AP/HTPB Composite propellant
D. Hybrid Rocket	iv. Hydrogen fuel

	A	B	C	D
a)	ii	i	iii	iv
b)	iii	iv	ii	i
c)	ii	iv	iii	i
d)	iii	i	ii	iv

2. If we double the rocket thrust by increasing the characteristic length scale, its weight goes up   CO1   [K₁]
    by a factor of _____.
    a) 2   b) $2^{3/2}$
    c) ½   d) $2^{1/2}$

3. Chemical Rocket will get maximum thrust when the ratio of the atmospheric pressure to the   CO2 [K₂]
    nozzle exit pressure (P_{atm}/P_{exit}) is _____.
    a) one   b) 1.8
    c) 1.4   d) ∞

4. In a quiet atmosphere, the force(s) which determine the trajectory of a stable powered rocket without misalignment is/are _____.   CO1 [K2]

a) Only gravity force   b) Thrust and Drag

c) Only thrust force   d) Gravity, Thrust and Drag

5. Assertion (A): At the optimum nozzle expansion the thrust of chemical rockets with identical   CO2 [K2]
chamber pressure at the sea level and the outer atmosphere will be different.

Reason (R): Thrust coefficient of chemical rockets at the optimum expansion will be higher at higher altitude due to the high momentum thrust as a result of low atmospheric pressure.

a) Both A and R are Individually true and   b) Both A and R are Individually true but
R is the correct explanation of A   R is not the correct explanation of A

c) A is true but R is false   d) A is false but R is true

6. While also as a fuel, which one of the following ingredient lowers the temperature of ignition   CO4 [K1]
and increases the speed of combustion of rocket igniters?

a) HTPB   b) Charcoal

c) Sulfur   d) AP

7. From the below list of four different types of rockets, identify the best sequence of a multi-   CO1 [K2]
staging starting from the first booster stage for getting the maximum ΔV.

(1) Nuclear rocket (2) Solid rocket (3) Hybrid rocket (4) Cryogenic

a) 2-3-4-1   b) 1-3-2-4

c) 3-4-2-1   d) 4-1-3-2

8. _____ is characterized by the supersonic flame propagation velocities.   CO4 [K1]

a) Deflagration   b) Detonation

c) Sonic combustion   d) Subsonic combustion

9. Assertion (A): In a multistage stage rocket the stages with higher specific impulse should be   CO3 [K2]
above stages with lower specific impulse for getting high ΔV.

Reason (R): In a multistage stage rocket similar stages should provide the same ΔV.

a) Both A and R are Individually true and   b) Both A and R are Individually true but
R is the correct explanation of A   R is not the correct explanation of A

c) A is true but R is false   d) A is false but R is true

10. Which propulsion device do not carry an active main propulsion system nor any propellant   CO3 [K2]
for it?

a) Solar sail   b) Solid rocket

c) Nuclear rocket   d) Electric rocket

PART B (10 x 2 = 20 Marks)
(Answer not more than 40 words)

11. Define the total thrust and write down the thrust equation of a rocket. — CO1 [K₂]

12. Define specific impulse of a rocket. — CO1 [K₂]

13. Name any two different types of igniters used in solid propellant rockets. — CO4 [K₁]

14. Differentiate between deflagration and detonation. — CO4 [K₂]

15. What is the function of a rocket nozzle? — CO2 [K₂]

16. What is the purpose of staging of rockets? — CO3 [K₂]

17. Differentiate between *chugging* and *screeching* phenomena in liquid rockets. — CO3 [K₂]

18. Name any two different types of injectors commonly using in liquid rockets. — CO3 [K₂]

19. What is the purpose of nozzle-less propulsion? — CO5 [K₂]

20. What is solar sail? — CO5 [K₂]

Answer any FIVE Questions:-
PART C (5 x 14 = 70 Marks)
(Answer not more than 300 words)

Q.No. 21 is Compulsory

21. a) Describe briefly the working principle of a chemical rocket. (7) CO1 [K₂]

    b) Using the mass balance equation derive an expression for predicting the steady state chamber pressure of a solid rocket motor. (7) CO1 [K₃]

22. a) Describe briefly any one solid rocket igniter and discuss the effects of burning rate index and the igniter size on internal ballistics. (7) CO2 [K₂]

    b) Describe briefly the physical processes involved in solid rocket ignition and flame spread. (7) CO4 [K₂]

23. a) Using the momentum principle derive the rocket equation in terms of initial mass and final mass for the estimation of ΔV. (7) CO2 [K₃]

    b) A surface-to-surface missile has a maximum flight speed to jet speed ratio of 0.21 and the specific impulse equal to 204 seconds. Determine (i) Effective jet velocity, (ii) Mass ratio, (iii) Maximum flight speed, and (iv) Coasting period, for a burn out time of 8 seconds. (7) CO2

24. a) Describe briefly the staging of rockets and thrust vectoring. (7) CO3 [K₂]

b) A two-stage rocket has the following masses: 1st-stage propellant mass 120,000 (7) CO2 [K₃] kg, 1st-stage dry mass 9,000 kg, 2nd-stage propellant mass 30,000 kg, 2nd-stage dry mass 3,000 kg, and payload mass 3,000 kg. The specific impulses of the 1st and 2nd stages are 260s and 320s respectively. Calculate the rocket's total ΔV.

25. a) Describe briefly the working of a liquid rocket. (7) CO3 [K₂]

b) Explain briefly any two types of cooling techniques used in liquid rockets. (7) CO3 [K₁]

26. a) Describe briefly the design consideration of liquid rocket combustion chamber. (7) CO3 [K₃]

b) A rocket engine burning liquid oxygen and kerosene operates at a mixture ratio of (7) CO3 [K₃] 2.26 and a combustion chamber pressure of 50 atmospheres. If the nozzle is expanded to operate at sea level, calculate the exhaust gas velocity relative to the rocket from the following given design data. *Universal gas constant = 8,314.51 N-m/kg mol-K, Adiabatic flame temperature = 3,400 K, Gas molecular weight = 21.40, Specific heat ratio = 1.221.*

27. Write short notes on **<u>any four</u>** of the following. CO5 [K₂]

(i) Cryogenic Rocket (ii) Ion propulsion, (iii) Nuclear rocket propulsion, (iv) Antimatter propulsion (v) Satellite thrusters (vi) Hybrid rocket, (vii) Electric rocket propulsion, [K₁]

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