



INDIAN INSTITUTE OF TECHNOLOGY KHARAGPUR

End-Spring Semester Examination 2022-23

Date of Examination: 18 Apr 2023 Session: (FN/AN) AN Duration: 3 hrs. Full Marks: 50

Subject No.: AG30204

Subject: OFF-ROAD VEHICLE SYSTEMS

Department/Center/School: Agricultural and Food Engineering Department

Specific charts, graph paper, log book etc., required NO

Special Instructions (if any): Attempt all questions; Approximate points distribution is indicated against the corresponding question; Strictly, all components of a question must be answered at the same place; Make logical assumptions, wherever needed, and clearly state the reason and the value; No queries will be entertained during the examination

Q.1 (a) For a vertical reciprocating engine (neglecting mass of connecting rod), derive suitable expressions and make neat annotated diagrams, for: [1 x 5]

- Piston effort (F_p)
- Force along connecting rod (F_c)
- Thrust on cylinder side wall (F_N)
- Crank-pin effort (F_T) and Thrust on crankshaft bearing (F_B)
- Turning moment (T)

[Given connecting rod length (l), radius of crank circle (r), crank position from inner dead center (θ), inclination of connecting rod to the line of stroke (ϕ), Mean effective pressure (p), Bore (D)]

(b) If the dimensions of such a prototype vertical 4-stroke engine, running at 2,000 rpm, are: Bore 100 mm, Stroke 120 mm, Connecting rod length 250 mm, Mass of reciprocating parts (neglecting connecting rod) 1.1 kg, Gas pressure 700 kN/m^2 , determine the values of F_p , F_c , F_N , F_T , F_B , and T when in the expansion stroke crank is at 20° from top dead center: [3]

Q.2 (a) Explain with suitable graphs the importance and working principle of a flywheel in engine. (2)

(b) For a flywheel of uniform circular cross section having mass 'm', radius 'R', fitted to an engine that is operating between angular speeds of ω_1 (minimum) and ω_2 (maximum), derive an expression for the Fluctuation of Energy ΔE . [3]

(c) An engine, fitted with a flywheel, is designed to operate at an average angular speed of 800 rpm. During the operation of engine, the maximum change in kinetic energy in a cycle is 6,240 J. Calculate the moment of inertia (in kg.m^2) such that the fluctuation of the angular speed can be maintained within $\pm 1\%$ of its average value. [3]

Q.3 Engine test data of a 32 kW max power tractor is presented in the table below.

Maximum torque	160 Nm	Engine speed at maximum torque	1,200 rpm
Torque at maximum power	125 Nm	Engine speed at maximum power	2,400 rpm
High idle engine speed	2,600 rpm	Low idle engine speed	1,000 rpm

Explain the following terms, and calculate: [2 x 4]

- Engine Flexibility
- Speed droop
- Lugging ability
- Governor regulation (%)

Q.4 A four-stroke diesel engine consumes diesel fuel (Heating value = 45,200 kJ/kg) at the rate of 19.3 kg/h while running at a rated speed of 2,300 rpm, and producing 275 Nm of brake torque. The mechanical efficiency of this engine may be taken as 85%. Calculate the following: [2 x 4]

- a) Friction power
- b) Indicated thermal efficiency
- c) Brake thermal efficiency
- d) Brake specific fuel consumption

Q.5 A 2WD tractor weighs 13.94 kN on the rear wheels and 7.93 kN on the front wheels. Rear tires are 14.9-28 (actual width 0.38 m and actual diameter 1.20 m); front tires are 7.50-16 (actual width 0.19 m and actual diameter 0.71 m). The terrain is characterized by average cone index $CI = 1,200 \text{ kPa}$. In certain operation, actual forward speed of the tractor is 2.56 km/h at 1,800 engine rpm; transmission gear ratio is 75, differential gear ratio is 1.2 and final-drive gear ratio is 1.5; overall transmission efficiency can be taken as 80%. Determine: [2.5 x 4]

- a) Wheel slip
- b) Wheel numeric (mobility number) for rear and front wheels
- c) Motion resistance ratios and rolling resistances for rear and front wheels
- d) Drawbar pull developed by the tractor at the given slip

Q.6 Write short-notes on: [2 x 4]

- a) Charge and discharge chemistry of lead-acid battery
- b) Cold power rating vs Reserve capacity rating
- c) Coefficient of fluctuation of speed vs Coefficient of fluctuation of energy
- d) Turbocharger vs Supercharger

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