**Railway Dynamics**

**Using the following empirical formulae to calculate the here-after problems: -**

|  |  |
| --- | --- |
| **Passenger trains (Shymaa formulae)** | **Freight trains (Intrenational formulae)** |
| **R r + a  = 0.0002 S2+0.0151 S + 1.4962**  **R c =39.819 rh – 0.549**  **μ = 0.0559 S2 – 6.5953 S + 331.59**  **ef = 3( S/1000)2 – 1.1(S/1000) +0.2065 for ( e = 0.95 )** | **R r + a  = 2.2 +3[ ( S + 15 ) / 100 ] 2 (kg/ton)**  **R c = 630 / rh (kg/ton)**  **μ = 9000 / (42 + S) + 116 (kg/ton)**  **ef = 5.8 (S /1000 ) 2 – 1.7 ( S /1000 ) + 0.2289 for ( e = 0.95 )** |
| **Rs = 12.8 (kg/ton)** | |

**Question 1**

**a) Define using sketches and equations: the tractive force, resistances, maximum speed, and critical speed, aero plane speed.**

**b) Draw neat sketches to show the following railway dynamics concepts, using equations or conditions:**

1. **Relation between train speed (S) and both (FP` ,Fμ`, Rr+a, la, a)**
2. **Stages to reduce the maximum horizontal force required to move a mass of (W) (ton) weight on a plane surface has coefficient of friction (µ).**
3. **Forces acting on both driving running wheel and braked one**
4. **Lateral automatic balance of coned wheel for classic trains**
5. **Lateral automatic balance of Magnetic Levitation Trains ( maglev)**

**c) What are the functions or the definitions of the following technical terms?**

**Critical Speed and Maximum Speed, Lubricants between axle and wheel, Bogies, Soft Sand, Braking Shoe**

**d) What is the difference between the following?**

**Freight Trains and Passenger Ones**

**Brake–Van and Luggage –Van**

**Car- Coaches- Wagons and Van**

**Goods – Cargo and Freight**

**The factor (h) for rotation, average power, and brake ratio**

**e) Prove the following relations:**

**1- la = ta \* (S1 +S2) / 7.2**

**2 – la = 4.2 (S22– S21 ) / F’ a average**

**3 - ta = 30.24 (S2 – S1) / F’ a average**

**4- lb = 4.2 (S21 – S22 ) / F’ b average + (t1 + t2) S1/ 3.6**

**5- tb = 30.24 (S1 – S2 ) / F’ b average + (t1 + t2)**

**Question 2**

**Complete the following table**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Train Type** | **Max Speed (kph)** | **Gradient ‰** | **Loco Power**  **(HP)** | **Loco Type** | **Loco Weight**  **(ton)** | **(Car Weight) \* (Car/ Train)** |
| **Passenger** | **SP=?** | **6** | **2750** | **C-A1A** | **135** | **52 \* 10** |
| **Empty Freight** | **SEF=?** | **-6** | **22\*58** |
| **loaded Freight** | **SLF=?** | **-6** | **85\*58** |
| **Passenger** | **SP= 12O** | **6** | **\*(HP) mimimum** | **C-A1A** | **135** | **52 \* 10** |
| **Empty Freight** | **SEF=60** | **-6** | **22\*58** |
| **loaded Freight** | **SLF=45** | **-6** | **85\*58** |
| **Passenger** | **SP= 12O** | **\*\*Max Gradient ‰ = ?** | **2750** | **C-A1A** | **135** | **52 \* 10** |
| **Empty Freight** | **SEF=60** | **22\*58** |
| **loaded Freight** | **SLF=45** | **85\*58** |
| **Passenger** | **SP= 12O** | **6** | **2750** | **C-A1A** | **\*\*\*135** | **52 \* NP** |
| **Empty Freight** | **SEF=60** | **-6** | **22\*NEF** |
| **loaded Freight** | **SLF=45** | **-6** | **85\*NLF** |

**Notes:**

**\* Calculate the minimum locomotive power in (HP), it must also pull all these trains when it stops for a long time in a very cold temperature.**

**\*\* Calculate the maximum upgrade; it must also pull all these trains when it stops for a long time in a very cold temperature.**

**\*\*\* Calculate also the maximum length of the passenger trains and freight ones, Knowing that: locomotive length=22m, passenger cars having- 25m length and freight cars having- 16 m length while brake-van length =19 m**

**Question 3**

**Calculate the following:**

**a) The ruling grade (Rc+g) on which a passenger train having J =4 can climb with max speed double of that for freight one having J =1**

**b) The relative horsepower (J =HP/ W) for a locomotive which permit it to pull a train uphill a grade with max speed 60 kph and downhill it with speed 120 kph.**

**c) The max speed (Smax) with which a train can go up a grade 5‰ and go down it with max speed =1.5 Smax**

**Question 4**

**a) Calculate Scritical and Smax for a train composes of a locomotive 120 ton weight,2500 HP power, type A1A-A1A and eight passenger cars of 47 ton weight each on a grade 5‰, What are the aero plane speeds and the corresponding power to ensure that this train runs as air couched train?**

**b- A freight train runs with max. Speed 50 kph on a grade 6 ‰, it composes of a locomotive 120 ton weight and 33 cars (21 cars have braking systems) of 50 tons weight each and a brake –van has 45 ton weight.**

**Calculate the speed with which the freight train will collide an obstacle on the track 150m apart, consider that the coefficient (e) = 0.92**

**Question 5**

**Calculate the delay in travel time for a passenger train moving with its maximum speeds (S max up and S max down ) in the up and down directions respectively on a steel bridge having a constant gradient = 11 ‰ due to reducing its speeds to the allowable speed which was set to 8 kph during its maintenance. Bridge length = 3116 m. The train consists of a locomotive type A1A-A1A which has 2450 hp power, 21.50 m length and 125 t weights, to pull 9 cars of 53 t weight, and 22.70 m length.**

**Plot the above-calculated problem on two graphs, the first one is for the up passenger train and the other for the down passenger train. The x-axis represents the distances in (meters) while the y-axis represents both the corresponding time (in seconds) and speed in (kph)**

###### Question 6

###### a) A passenger train departs from station “A” at 7:55 am , calculate when the train arrives to station “B” which locates 18.4 km apart from station “A”, the train also passes by a through block section “C” which locates 9.1 km apart from station “A”. The “ACB” line is single and straight, with constant grade= + 3‰. The passenger train composes of a locomotive (135 tons weight, 2475 HP power, and (B-A1A) type). It pulls 11 cars of 51 tons weight/car

###### b) If an express train departs just after the passenger train from station “A” to station “B”, calculate the minimum interval time (Tocf) to permit the express safely depart , on condition that the passenger train will stop at “C” till the express passes by “C” without stopping.

###### Note: the express train composes of a locomotive (130 tons weight, 3500 HP power, and (C-C) type). It pulls 9 cars of 50 tons weight/car

###### c) In the second case, calculate the minimum stopping time of the passenger train at “C” and when it will arrive at station “B”, knowing that the express will pass by both “C” and station “B” without stopping

**Question 7**

###### A freight train is used only to transport iron ore from mine station (A) to steel factory (B) by the use of a single line which consists of two gradients, one is upwards to the factory (g1) and the other is upwards to the mine (g2). If the train composes of : -

###### Two locomotives (2475 HP power, 150 ton weight, type: A1A – B) for each locomotive, 58 non-braked cars (23 t own weight, 65 t load) for each car, and a brake-van of 40 ton weight.

###### Calculate the maximum values of the two gradients, if the maximum permissible speed is 45 k/h and the weather is very cold at this district.

###### Assuming that the two gradients (g1 & g2) are constants with 15.436, and 18.349 km length respectively, calculate the average and commercial train speeds in the two directions, if the trains stop only at the mine station and at the factory one for 25 minutes at each station.

###### Compare between the two alternatives for track alignment (from the mine to the factory direction):

###### - the gradient g1 is followed by the gradient g2

###### - the gradient g2 is followed by the gradient g1

1. **Design the vertical curve connecting the two gradients.**

**Question 8**

###### A freight train is used only to transport iron ore from mine station (M) to steel factory (F) by the use of a single line is upwards to the factory, if the train composes of: Two locomotives (2475 HP power, 138 ton weight, type: A1A – B) for each locomotive, 59 non-braked cars (22 t own weight, 68 t load) for each car, and a brake-van of 45 ton weight. ABCDE is a part of above- mentioned single line, having the following characteristics: ABC has a constant grade (g1) = 1 ‰, while CDE has a constant grade (g2) = g max ‰ “A” and “B” are the two tangent points of the curved track ‘AB’ which has P1 = + 1.425 curvature and ɑ1 = 55 o central angle

###### “D” and “E” are the two tangent points of the curved track ‘DE’ which has P2 = - 1.325 curvature and ɑ2 = 38 o central angle

###### “C” is the theoretical point of gradient change between grade (g1) and grade (g2) which locates at km: 203 +156 at level: (12.36)

###### It is required to:

###### - Calculate the maximum permissible gradient (g max), if the maximum speed is S future which is corresponding to maximum super elevation = 135 mm. consider that the weather is very cold at this district.

###### -Design the vertical and horizontal curves elements.

###### -Draw plan super elevation (e) and curvature (r).

###### - Tabulate the calculations in a table containing kilometer, gradient, left rail level, right rail level, curvature line and the corresponding central angle (ɑ) and curvature (r).

**Question 9**

###### Passenger Magnetic Levitation Train has a 525 tons weight runs on a straight index with speed = 490 kph when the vertical distance (dvp= 5 cm) and the horizontal distances (dhpl = dhpr = 4 cm). hwp =215 cm , hvl = hvr = 4.5 cm.

###### a) Calculate the horizontal curve radius of curved index corresponding to lateral shift (xp) = 1.8 cm. assume c`mi` mt` = c mi mt

###### b) Calculate also:

###### - The speed of freight Magnetic Levitation Train has a 1650 tons weight runs on the same straight index

###### - The corresponding vertical distance (dvf)

###### - The lateral shift (xf) corresponding to above horizontal curve radius of the curved index if (dhfl= dhfr = 5 cm). hwf =255 cm , hvl = hvr = 4.5 cm