INDIAN INSTITUTE OF TECHNOLOGY KHARAGPUR

Class Test 1-Autumn Semester 2019-20 Solution

Date of Examination: 05/09/2019 Duration: 1 hrs Full Marks: 20
Subject No.: *ME10001* Subject: *Mechanics* Department/Center/School: All 1st Year UG

Ans 1

Column 1: Configuration	Is $\lvert\mathbf{M}_{a-a}\rvert = 0$?
Line of action of $\mathbf{F_1}$ intersects the axis *a–a* and that of $\mathbf{F_2}$ is parallel to the axis *a–a*	**YES**
Lines of action of both $\mathbf{F_1}$ and $\mathbf{F_2}$ intersect the axis *a–a*	**YES**
Lines of action of both $\mathbf{F_1}$ and $\mathbf{F_2}$ are parallel to the axis *a–a*	**YES**
$\mathbf{F_1}$ and $\mathbf{F_2}$ produce a couple moment and the direction of that couple moment is parallel to the axis *a–a*	**NO**

Ans 2. Answer: Members DF, CF, CG and BG to be crossed

Ans 3. In the truss given in Question No. 2, the magnitude of reactions at supports A and B are **4.12** *P* and **7** *P*, respectively.

Taking moment about point B in the FBD of the truss, reactions on the truss at A are $AA_{yy} = 4P$ (down) and from force balance in x direction, $AA_{xx} = P$ (to the left). From force balance in y direction $BB_{yy} = 7P$ (up).
So, magnitude of reaction at A is $\sqrt{17}\boldsymbol{P}$ or **4.123*P*** and that at point B is ***7*P**.

Ans 4. In the truss given in Question No. 2, the force in member AK is **tensile** and in member BK is **compressive** (Fill "compressive" / "tensile", as appropriate, in the blank space **without values**).

From solution in Q3, at Pin A FF_{AHH} and FF_{ABB} are tensile. From FBD of pin K, to balance component of vertical tensile force at the pin, FF_{BBHH} is compressive.

Ans 5. The *non-zero force members* of the truss given in Question No. 2, that can be replaced by strings are **AK, AB, KH, EF, GH, FG** (List all **six members**).

After removing zero force members, from FBD of Pin E, force in EF, FG and GH are tensile. Force in AK and AB are tensile from Q4. From FBD of pin H, if GH is tensile then HK is tensile.

Ans 6. The two-force member(s) in the frame is/are CD and BE.

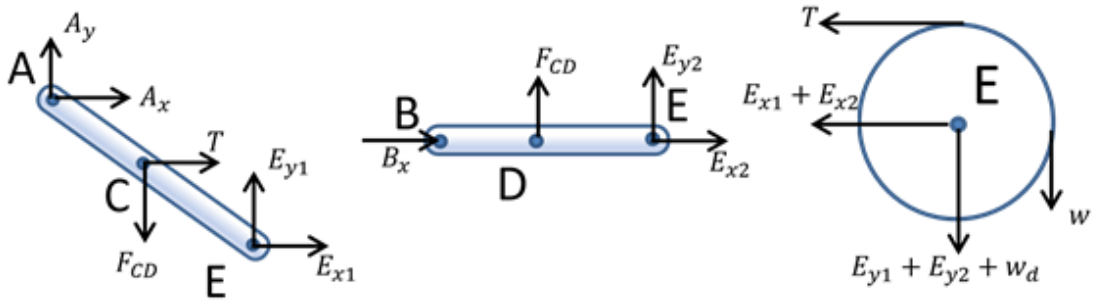
The magnitude of reaction at roller support B is 250 N.

Place for Solution: From the figure, CD=1.5 m. Thus, pulley radius is 1.5 m.

From FBD of whole system, taking moment about point A $4ww_{dd} + 5.5ww = 3BB_{xx}$, $BB_{xx} = \frac{750}{3}$ N $= 250$ N

Ans 7.

FBD of AE	FBD of BE	FBD of Pulley



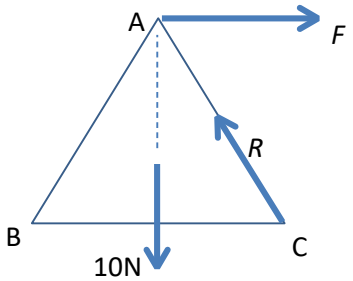
Note: Here, reactions at E are adjusted at pulley. It could be done at any other FBD.

Ans 8. For the frame in Question No. 6, the reaction force at pin D is _____0_____ N as computed from FBD of member BE by taking moment about point ____E_____.

Ans 9. The magnitude of the force *F* is 5.77 N.

The resultant ground reaction force at C acts along line AC or CA.

Solution: When the prism is just about to topple, the ground reactions act at point C only.



Since the body is acted upon by three forces only, and they are not parallel to each other, the line of action of those forces must meet at the common point A. Otherwise, moment at A cannot be balanced.

Thus, taking moment at point C, $\frac{\sqrt{3}}{2}F = 10 \times \frac{1}{2}$ or $FF = \frac{10}{\sqrt{3}}$ N or 11.55 N.

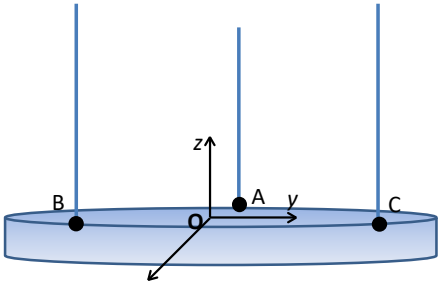
R acts long line AC.

Questions 10 and 11 Carry 3 Marks each (Only Integer Part Marking)

Ans 10.

Let tensions in the spring be TT_A, TT_{BB} and TT_{CC}. Taking moment about point O in the FBD of the disc,

$(-i) \times TT_A k + (0.6i - 0.8j) \times TT_{BB} k + (0.6i + 0.8j) \times TT_{CC} k = 0$



or $TT_A j - 0.6TT_{BB} j - 0.8TT_{BB} i - 0.6TT_{CC} j + 0.8TT_{CC} i = 0$, So $TT_A - 0.6(TT_{BB} + TT_{CC}) = 0$, $TT_{BB} = TT_{CC}$ **(1 Mark)**

From $\sum FF_z = 0$, $TT_A + TT_{BB} + TT_{CC} = 6.4$ kN. **(1 Mark)**

Since $TT_{BB} + TT_{CC} = TT_A/0.6$, $1.6\, TT_A = 0.6 \times 6.4$ kN or $TT_A = 2.4$kN. Then $TT_{BB} = TT_{CC} = 2$kN. **(1 Mark)**

Ans 11. To determine force in member HK, moment about point ___B_____ needs to be taken in that FBD. The force in member HK is __3___ P Tensile ~~/Compressive~~ (Strike off the incorrect part).

FBD of the Section and Solution:

Consider the section cutting through members HK, BH, BG and BC. (Note that BG is zero-force member and may not appear in the FBD).

Taking moment about point B, $FF_{HHHH} = 3P$ (tensile)