CONNECTED PARTICLES

Lesson Five

By

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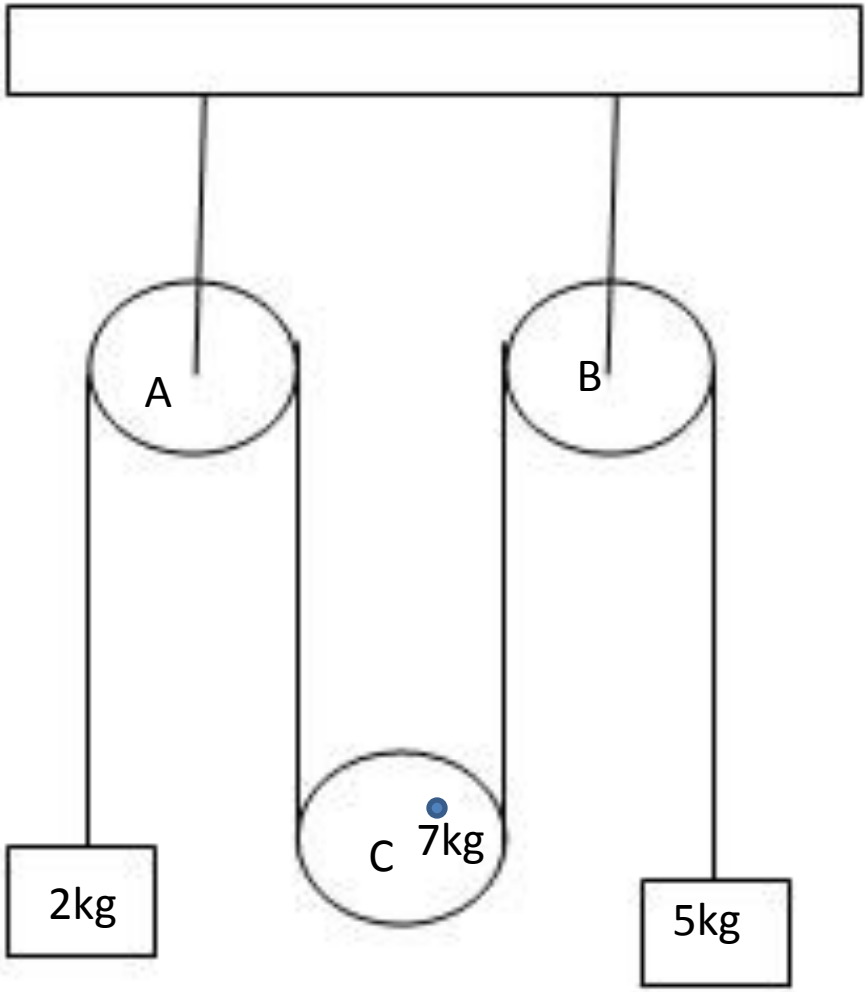
Related accelerations

- In cases of connected particles and moveable pulleys or bodies in contact where each body is free to move, each part of the system is assumed to have different accelerations until proved otherwise through calculations. However a relationship between the accelerations can be established through the analysis of the physical properties of the system.

EXAMPLE-Diagram



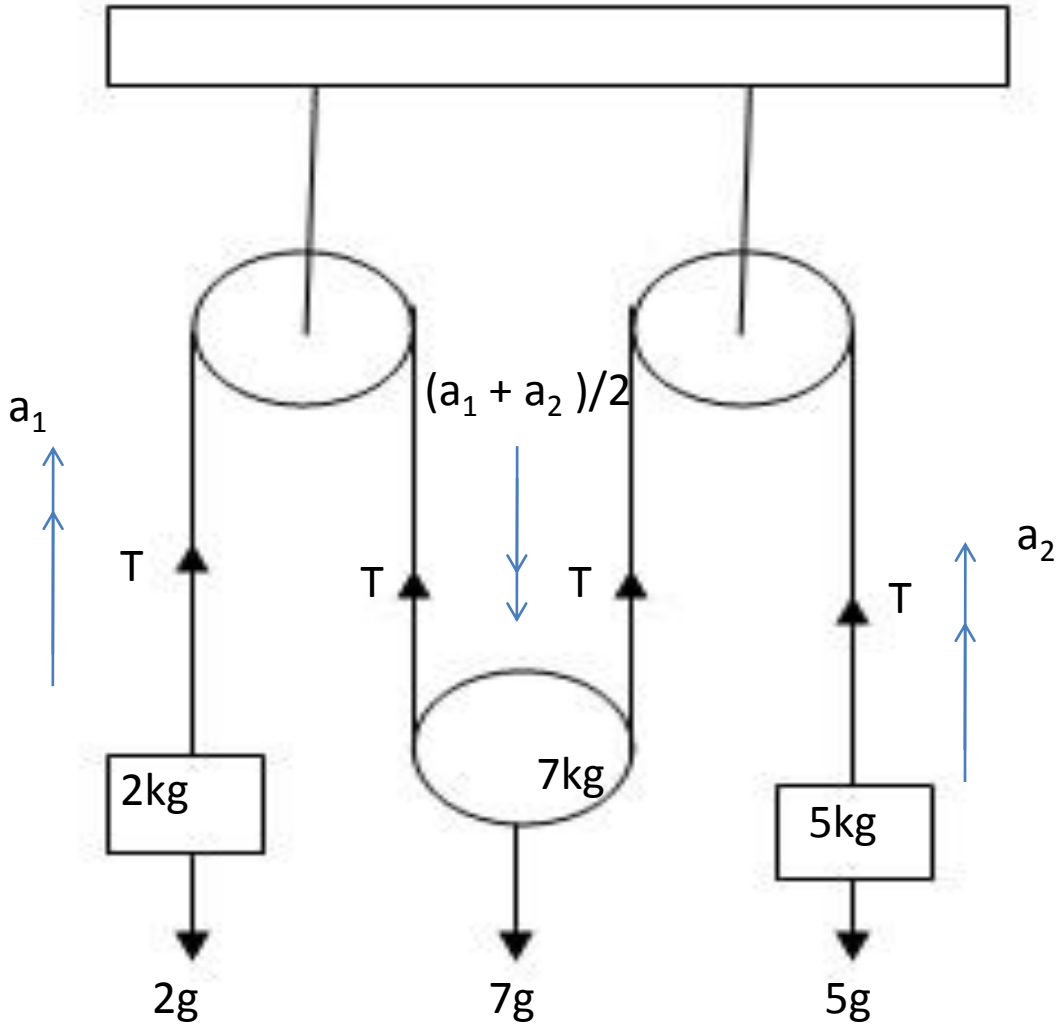
QUESTION

The diagram above shows particles of masses 2kg and 5kg connected by a light inextensible string passing over two fixed smooth pulleys A and B and under a light smooth moveable pulley which carries a mass of 7kg. The system is released from rest when all the parts of the string are taut and straight.

Calculate (i) the acceleration of the particles and that of the pulley

(ii) the tension in the string.

Diagram showing all the forces



Notes

For the 2kg mass to go up a distance x m ,the pulley goes down a distance x/2 m. If the 5kg mass was to go up a distance y m then the pulley goes down a distance y/2 m. Thus if the 2kg and 5kg particles go up x and y distances respectively then the pulley goes down (x + y)/2 distance. Hence if the upward acceleration of the 2kg and 5kg masses was a_1 and a_2 respectively , then the acceleration of the pulley downwards will be $(a_1 + a_2)/2$.

Equations of motion

For the 2kg mass;

$T - 2g = 2a_1$ ……(i)

For the 5kg mass;

$T - 5g = 5a_2$ ……(ii)

For the moveable pulley

$7g - 2T = 7(a_1 + a_2)/2$…(iii)

Solving the equations

5x(i) + 2x(ii)

$5T - 10g = 10a_1$

$+2T - 10g = 10a_2$

$7T - 20g = 10(a_1 + a_2)$….(iv)

Solving 7x(iii) + 2x(iv)

$49g - 14T = 49(a_1 + a_2)/2$

$+14T - 40g = 20(a_1 + a_2)$

$9g = 89(a_1 + a_2)/2$

$9g/89 = (a_1 + a_2)/2$….(v)

Finding the accelerations and the tension

From (iii)

$7g - 2T = 7(a_1 + a_2)/2$

$7g - 2T = 7X\ 9g/89$

$2T = 7g - 63g/89$

$2T = 560g/89$

$T = 280\ X\ 9.8/89$

$T = 30.83146N$

The tension in the string is

<u>30.83146N</u>

From $T - 2g = 2a_1$ …….(i)

$280g/89 - 2g = 2a_1$

$(280 - 178)g/89 = 2a_1$

$2a_1 = 102g/89$

$a_1 = 51g/89$

$a_1 = 5.61573ms^{-2}$

The positive sign of the acceleration confirms direction assumed at the start. Hence 2kg mass goes up with **<u>$5.61573ms^{-2}$</u>**

Calculations

From $T - 5g = 5a_2$

$280g/89 - 5g = 5a_2$

$5a_2 = (280 - 445)g/89$

$5a_2 = -165g/89$

$a_2 = -33g/89$

$a_2 = -3.63371 ms^{-2}$

The negative sign of acceleration indicates that the direction of motion assumed was the opposite to the true direction. Hence 5kg particle goes down with **$3.63371 ms^{-2}$** .

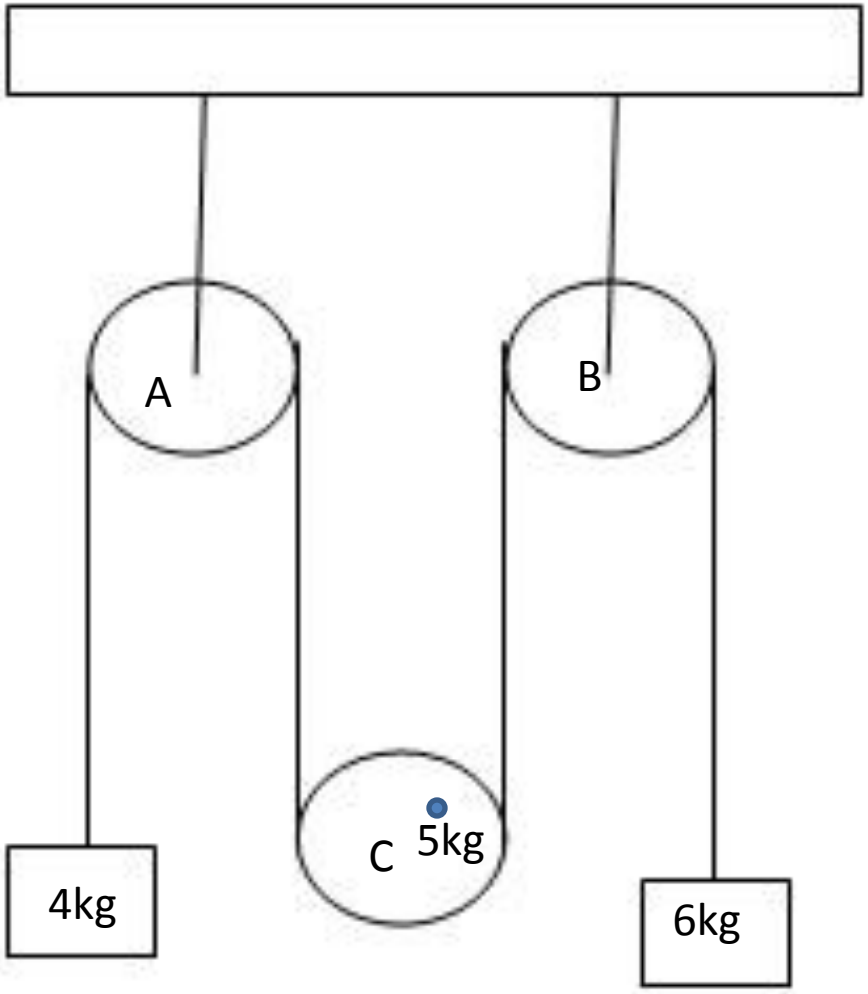
Thus the acceleration of the moveable pulley upwards is;

$(a_1 + a_2)/2 = (51g/89 - 33g/89)$

$= (18 \times 9.8)/89$

$=$ **$\underline{1.982022\ ms^{-2}}$**

HOME WORK-Diagram



QUESTION

The diagram above shows particles of masses 4kg and 6kg connected by a light inextensible string passing over two fixed smooth pulleys A and B and under a light smooth moveable pulley which carries a mass of 5kg. The system is released from rest when all the parts of the string are taut and straight.

Calculate (i) the acceleration of the particles and that of the pulley

(ii) the tension in the string.

RESEARCH

http://thephysicsteacher.ie/appliedmathshome.html (Look for the column with pulleys and wedges and click on the word document. Save it on your computer and use it as revision document. However do not read about moving wedges because this is off our syllabus).

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