Quiz Topic: Dynamics
Possible Score: 26 Marks
Level of Difficulty: High

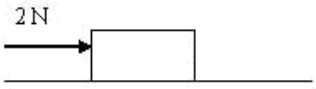
1. Two girls, Lynn and Denise, are pulling a rope with a ribbon attached to the rope as shown below. Lynn is pulling the rope with a horizontal force of 550 N while Denise is pulling the rope with a horizontal force of 700 N.

(a) Calculate the net force on the rope. In which direction will the ribbon move? (1)

(b) The two girls have the same mass of 35 kg each and the rope and ribbon have a combined mass of 5 kg. Calculate the acceleration of the ribbon. (2)

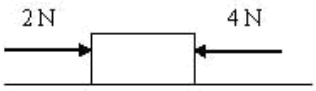
2. A 2.0 kg mass has an initial speed of 2.0 ms^{-1}. It is moved along by various forces as shown. For each scenario, sketch the velocity-time graph for the first 8.0 s of its motion, showing appropriate workings where necessary. (6)

Scenario 1:

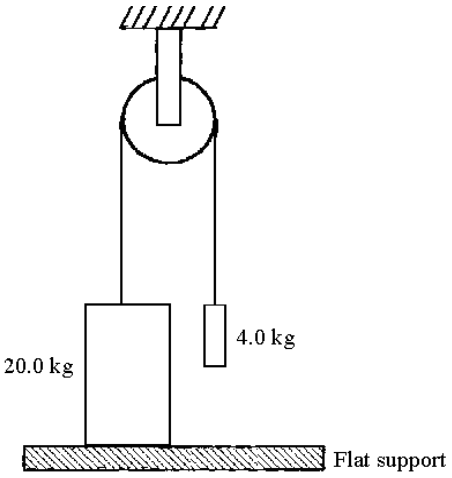


Scenario 2:

Scenario 3:



3. Two masses, 20.0 kg and 4.0 kg, are connected to two ends of a rope that passes over a smooth pulley as shown in the diagram.



(a) Mark and label on the diagram, all the forces acting on the two masses. (2)

(b) The flat support is removed.

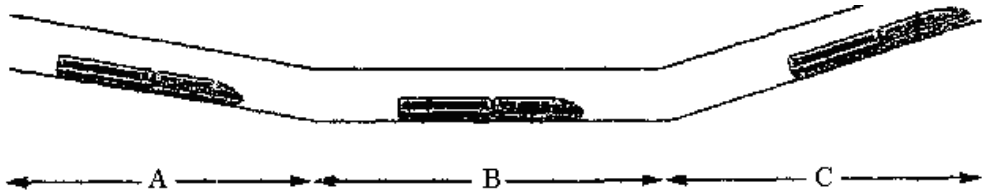
(i) State the subsequent motion of the masses. (1)

(ii) Calculate the acceleration of the connected masses. (2)

4. The mass of a train is 2 x 10^6 kg. The engine produces a forward force of 200 kN. While accelerating, the average drag force is 80 kN.

(a) Calculate the average acceleration of the train. (2)

(b) The train enters a tunnel as shown in the figure below, travelling downhill (A), horizontally (B) and uphill again (C).



For safety reasons, the train must maintain a steady speed through the tunnel. Even though the speed remains steady, the driving force from the motors varies.

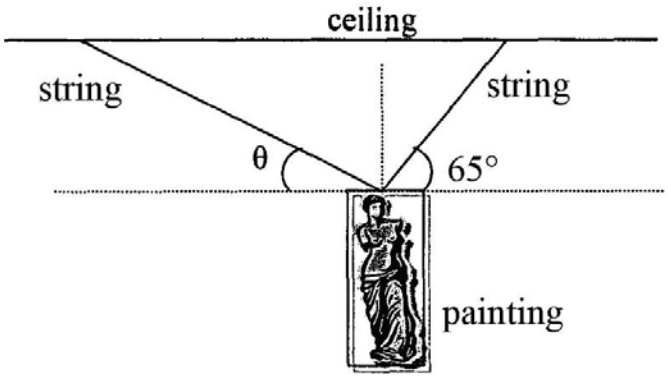
State whether the driving force from the engine motor is greater or lesser than, or equal to, the drag force of 80 kN along each of the following parts of the journey. You may assume that the average drag force remains the same.

(i) Downhill stage (A)

(ii) Horizontal stage (B)

(iii) Uphill stage (C) (3)

5. Amber wants to hang a painting in a certain way. The diagram below shows what she has in mind.



(a) Draw and label, on the diagram, all the forces acting on the painting. (2)

(b) The tension in the right string is 10 N and the weight of the painting is 12 N. By means of a scaled diagram, find the magnitude and direction θ of the tension of the left string. (4)

Answers:

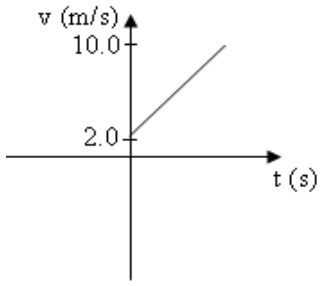
1(a) Net force = 700 N – 550 N
= 150 N

Direction: To the right; backwards from Denise

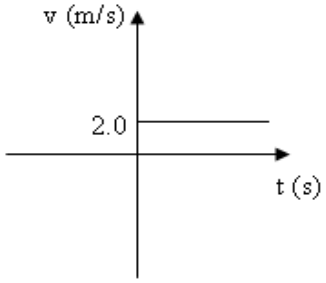
(b) F = ma
150 N = (5 kg) (a)
a = 30 m/s^2

2. Scenario 1: F = ma
2 N = (2.0 kg) (a)
a = 1.0 m/s^2

a = (v – u) / t
1.0 m/s^2 = (v – 2.0 m/s) ÷ 8 s
v = 10.0 m/s

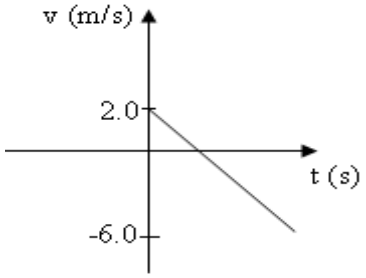


Scenario 2:
No net resultant force. Hence object moves at constant velocity of 2.0 m/s.

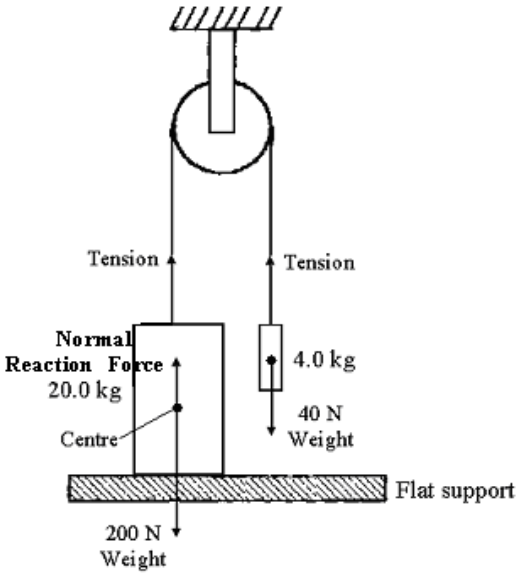


Scenario 3: F = ma
2 N – 4 N = (2.0 kg) (a)
a = -1.0 m/s^2

a = (v – u) / t
-1.0 m/s^2 = (v – 2.0 m/s) ÷ 8 s
v = -6.0 m/s



3(a)



Comments:

√ *The four forces are:*
- *2 x T*
- *200 N*
- *40 N*
- *Normal Reaction*

√ *Marks will be deducted for the incorrect labelling of each force's direction and position, as well as including forces that are not supposed to be there.*

(b)(i) The 20 kg mass accelerates downwards and the 5 kg mass accelerates upwards.

(ii)
$$F = ma$$
$$200\ N - 40\ N = (20\ kg + 4\ kg)\ (a)$$
$$a = 6.666$$
$$= \underline{6.7\ ms^{-2}}\ (2\ sf)$$

4(a)
$$F = ma$$
$$(200 \times 1000\ N) - (80 \times 1000\ N) = (2 \times 10^6\ kg)\ (a)$$
$$a = \underline{0.060\ ms^{-2}}$$

(b)(i) Driving force is smaller than 80 kN.

Comment:

√ *The driving force, together with the weight of the train along the slope, will balance the average drag force.*

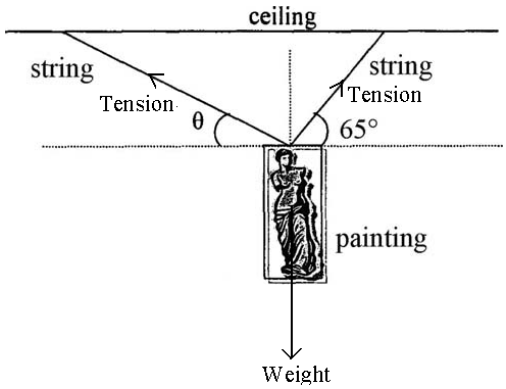
(ii) Driving force equals to 80 kN.

(iii) Driving force is greater than 80 kN.

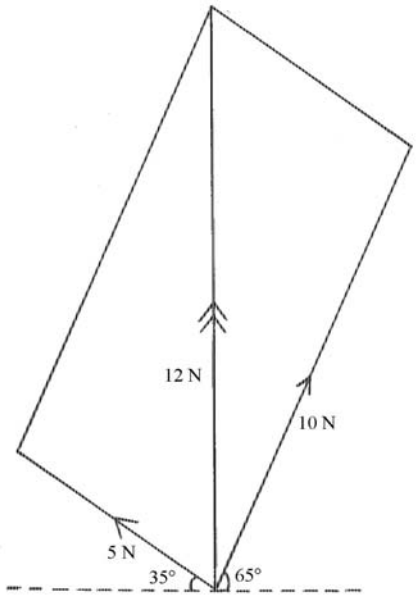
Comment:

√ *The driving force must be greater than 80 kN in order to balance the average drag and the weight of train along the slope*

5(a)



(b) Scale: 1 cm: 1 N



Tension = <u>5 N</u>
θ = <u>35°</u>