O Level Pure Physics Structured

Forces Test 2.0

Q1

Fig. 1.1 shows a man pulling a truck of logs along a level path from P to Q against a resistive (frictional) force.

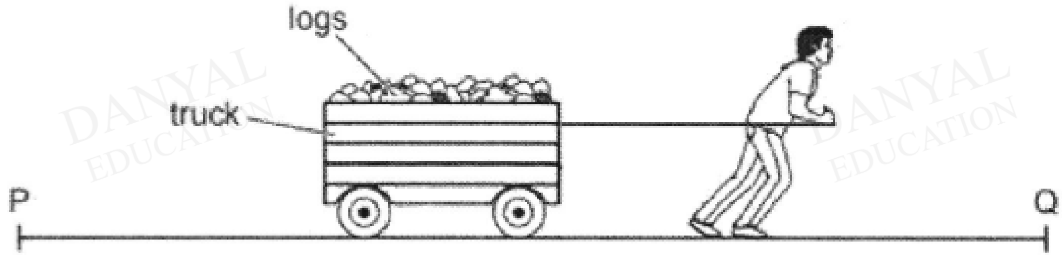


Fig. 1.1

(a) In Fig. 1.1, draw all the forces acting on the truck. Label all the forces clearly. [2]

(b) When the truck is just leaving its initial rest position, state if the pulling force exerted by the man is the same or larger than the resistive force. Explain your answer.

....

.... [1]

(c) An accurate value for the force applied by the man is obtained. Describe what measurement is taken and how it is used to determine the average force.

....

.... [1]

(d) The man calculates his power when he moves from P to Q.

(i) Apart from the measurement in **(c)** and the distance moved by the truck from P to Q, state the additional quantity that is needed.

....

.... [1]

(ii) State, in words, the equations needed to calculate the man's power.

....

....

....

.... [2]

Q2

Fig. 1.1 shows a helicopter taking off vertically. It starts from rest at time t = 0 s, and has a constant upward acceleration of 0.80 m s^{-2}. The mass of the helicopter is 2000 kg. The acceleration due to free fall is 10 m s^{-2}.

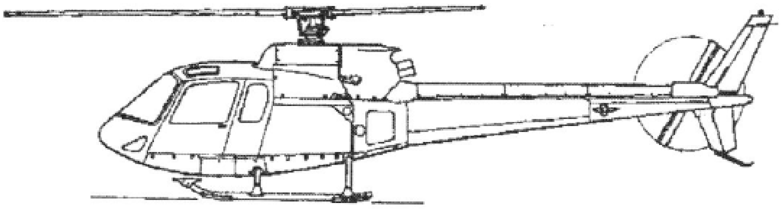


Fig. 1.1

(a) On Fig. 1.1, draw the forces acting on the helicopter. [1]

(b) Calculate the upward velocity of the helicopter at 25 s.

velocity = ... [2]

At 25 s, a box accidentally dropped from the helicopter. At this moment, the box has the same velocity as the helicopter as calculated in **(b)**.

(c) Given that the box eventually falls at terminal velocity, sketch the velocity-time graph of the box. [1]

(d) Explain, in terms of forces, how the acceleration changes when the box is initially dropped to the time when it falls at terminal velocity.

....

....

....

.... [3]

Q3

It is a well-known fact that the maximum stopping distance travelled by a car depends on many factors. Two of the physical factors – road condition and the condition of the tyres – which determine whether the car stops or skids on braking is considered in this situation here.

Fig. 9.1 shows how the maximum possible friction between a car tyre and the road varies with the speed of the car, in wet road conditions.

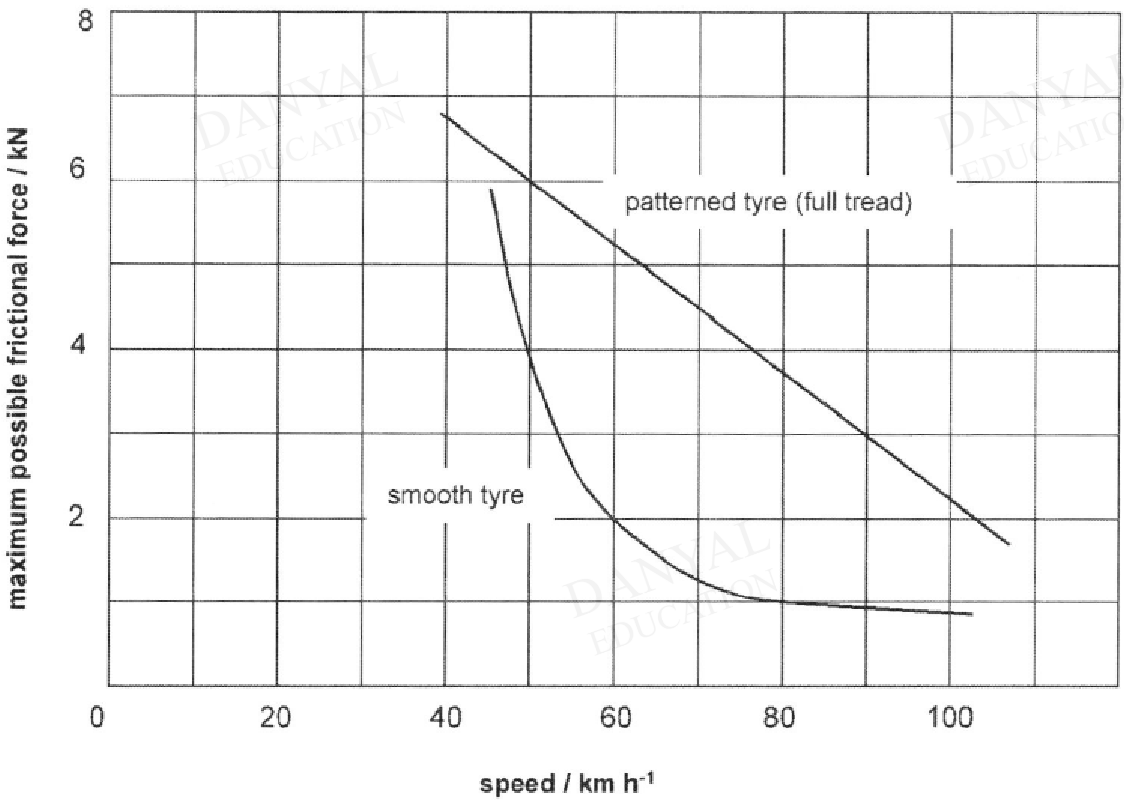


Fig. 9.1

(a) Describe how fig. 9.1 shows that using a patterned tyre is safer than using a smooth tyre.

....

.... [1]

Fig. 9.2 shows the tread pattern of the patterned tyre.

Patterned tyre

(full tread)

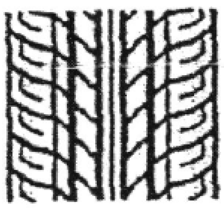


Fig. 9.2

(b) With reference to Fig. 9.2, explain how does the tread pattern help the patterned tyre achieve a greater frictional force as compared to the smooth tyre in wet road conditions.

....

.... [2]

In addition to the frictional forces between the tyres and the road, the car also experiences air resistance. The air resistance F_{air} experienced by a car at any speed v (in km h^{-1}) is given by the equation

$$\mathbf{F_{air}} = \boldsymbol{kv^2}\text{, where } k \text{ is a constant.}$$

A car with **patterned tyres** is moving on a **wet** road at a constant speed of 50 km h^{-1}. The total mass of the car and its passengers is 900 kg.

(c) If the air resistance experienced by the car at that speed is 5.0 kN, determine value of the constant k.

k = ... [2]

The car's speed is now increased to a new constant speed of 90 km h^{-1} in 5 s.

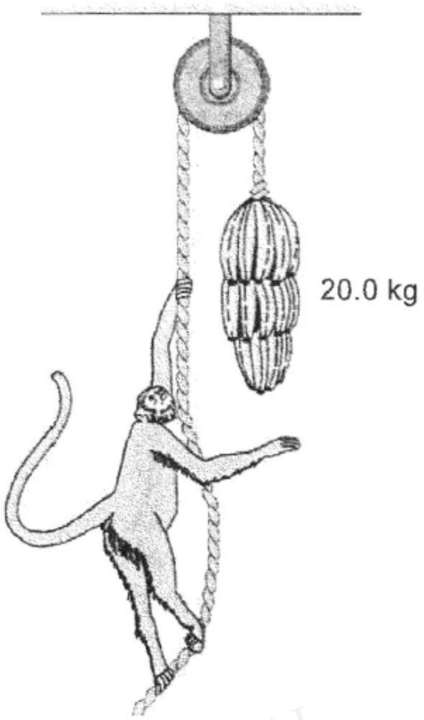
(d) Calculate the acceleration of the car in m s^{-1} in the 5s when the speed is increasing.

acceleration = ... m s^{-1} [2]

(e) Calculate the driving/forward force of the car when it is travelling at a constant speed of 90 km h^{-1}.

driving force = ... N [3]

Q4
A monkey has a firm hold on a light rope that passes over a frictionless pulley and is attached to a 20.0 kg bunch of bananas as shown below.



The monkey and the bananas are balanced.

(a) Write down the weight of the monkey.

.... [1]

(b) Upon seeing the delicious bananas, the monkey starts to climb the rope to get them. The monkey applied a force on the rope that caused itself to accelerate at 0.50 m s^{-2} upwards, all the while hanging on to the rope.

(i) Calculate the magnitude of the force that the monkey applied on the rope.

Force = ... [2]

(ii) Describe the motion of the bunch of bananas.

....

.... [2]

Q5

A container of mass 2000 kg is hoisted by an electrically operated crane as shown in Figure 1, in order for it to be loaded onto a ship. Initially the container is accelerated upwards briefly, after which it is hoisted at a constant speed.

Physical System

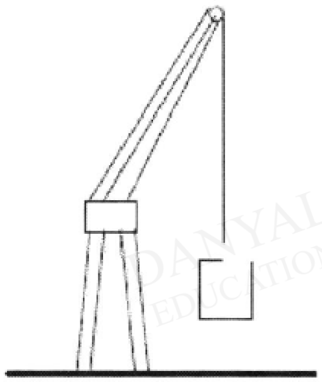
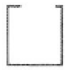


Figure 1

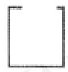
Free Body Diagram



accelerating upwards

Figure 2

Free Body Diagram



moving upwards at constant speed

Figure 3

a. On Figures 2 and 3 above, draw free-body force diagrams showing and labelling the forces acting on the container during the stages of acceleration and constant velocity. Use longer vectors for greater forces.

[2]

b. The safety limit for the tension in the cable is 25000 N.
Determine the maximum permissible upward acceleration of the container if the limit is not to be exceeded.

[2]

c. After the initial acceleration, the crane continues hoisting the container at a constant upward speed of 0.5 ms^{-1}.

i. Calculate the power output of the crane during this stage.

[2]

ii. The crane's electric motor operates at 400 V.
Assuming no power losses, calculate the current drawn by the motor during hoisting.

[2]

iii. Eventually the container reaches a height sufficient for loading onto the ship. To what energy has the electrical energy supplied to the motor be converted into? [1]

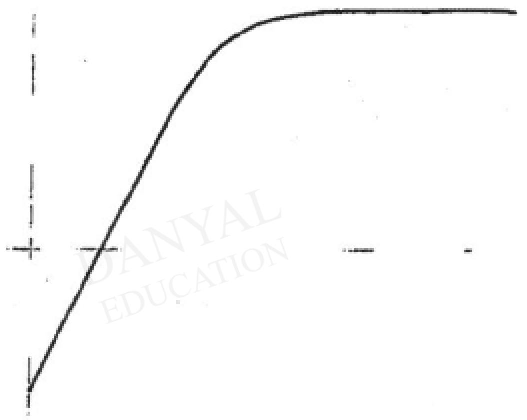
Answers

Forces Test 2.0

Q1

1a	• Normal reaction force • Weight • Friction • Tension (force of logs on truck)	0.5 M for each ans. Round down
1b	Pulling force is larger than friction so that net force is needed to accelerate load.	1
1c	Attach a newton balance to the rope to measure force.	1
di	Time taken for the truck to move from P to Q.	1
dii	• Work done by man = Force applied by man × distance between P and Q • Power = work done by man / time taken for the truck to move from P to Q	1 1

Q2

a	Upward lift force and downward weight force with label	B1
b	a = (v-u) /t or 0.8 = (v-0) / 25 $v = 20\ ms^{-1}$	M1 A1
c		B1
d	initially acceleration > $10\ m\ s^{-2}$ because there is weight acting on the box and air resistance (acting downward) as velocity increases, air resistance increases and the resultant downward force decreases, acceleration decreases when air resistance equals weight, resultant force = 0 thus acceleration = 0 (terminal velocity)	B1 B1 B1

Q3

a	Graph for the patterned tyre is higher than the curve for smooth tyre / patterned tyre registers a higher friction compared to smooth tyre over different speeds.	B1
b	Grooves in patterned tyres channel water away from centre to its sides for more grip	B1
	Smooth tyres (no channels) maintains a layer of water between tyre and road surface. Frictional forces in smooth tyres is therefore less.	B1
c	$F_{air} = kv^2$ or $5.0\text{ kN} = k(50\text{ kmh}^{-1})^2$	M1
	$k = \frac{5.0}{2500}\frac{kN}{km^2h^{-2}}$ $= 2\times10^{-3}\,kN\,km^{-2}h^2$	A1
d	$90\text{ km h}^{-1} = 25\text{ ms}^{-1}$, $50\text{ km h}^{-1} = 13.9\text{ ms}^{-1}$	
	a = (v-u) /t or (25 – 13.9) /5	M1
	$a = 2.22\text{ m s}^{-2}$	A1
e	At 90 kmh^{-1}, Frictional force = 3.0 kN	B1
	$F_{air} = kv^2$ $= (2\times10^{-3})(90)^2\,\frac{kN}{km^2h^{-2}}(km^2h^{-2})$	M1
	$= 16.2\,kN$ Driving force = 16.2 kN + 3.0 kN = 19.2 kN	A1

Q4

3a	200 N (2 or 3 s.f)	[1]
3bi	Taking upwards as positive, $F_R = F + W$ $F = F_R - W = (20.0 \times 0.50) - (-200) = 10.0 + 200 = 210$ N (2 or 3 s.f)	Working [1] Ans [1]
bii	The bunch of bananas will **accelerate upwards [1]** with an acceleration of **0.50 m s^{-2} [1]**.	[2]

Q5

Physical System

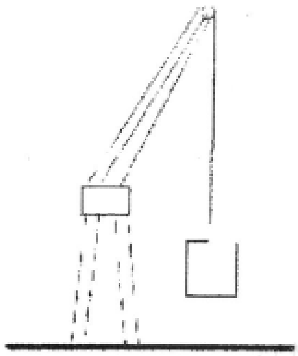
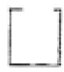


Figure 1

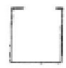
Free Body Diagram



accelerating upwards

Figure 2

Free Body Diagram



moving upwards at constant speed

Figure 3

a. On Figures 2 and 3 above, draw free-body force diagrams showing and labelling the forces acting on the container during the acceleration and constant velocity stages. Use longer vectors for greater forces.

[2]

b. The safety limit for the tension in the cable is 25000 N. Determine the maximum permissible upward acceleration of the container if the limit is not to be exceeded.

[2]

F = ma

25 000 – 20 000 = 2 000 x a A1

a = 2.5 ms^{-2} A1

c. After the initial acceleration, the crane continues hoisting the container at a constant upward speed of 0.5 ms^{-1}.

i. Calculate the power output of the crane during this stage.

[2]

Power = Work ÷Time = F x velocity

P = F x v A1

P = 12 500 w A1

ii. The crane's electric motor operates at 400 V. Assuming no power losses, calculate the current drawn by the motor during hoisting.

[2]

P = IV

12 500 = I x 400 A1

I = 31.25 A A1

iii. Eventually the container reaches a height sufficient for loading onto the ship. To what energy has the electrical energy supplied to the motor be converted into?

[1]

Electrical Energy to Gravitation Potential Energy A1