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Physics worksheet solutions – Newton's second law of motion

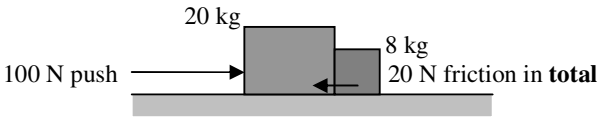
Q1 The acceleration of a car increases from 0.5 ms^{-2} to 2 ms^{-2}. Find the value of the ratio $\frac{net.force.after.the.change}{net.force.before.the.change}$.

$F_{net} \propto a$, .: $\frac{net.force.after.the.change}{net.force.before.the.change} = \frac{a_f}{a_i} = \frac{2}{0.5} = 4$

Q2 A truck of mass M kg carries a load of mass $0.5M$ kg. Determine the value of the ratio $\frac{acceleration.without.the.load}{acceleration.with.the.load}$, assuming that the driving force and resistive forces are unchanged.

$a \propto \frac{1}{m}$, .: $\frac{acceleration.without.the.load}{acceleration.with.the.load} = \frac{M + 0.5M}{M} = 1.5$

Q3



Determine the net force on the 8-kg box.

$a = \frac{F_{net}}{m} = \frac{100-20}{28} = \frac{80}{28}$, .: F_{net} on 8-kg box $= ma = 8 \times \frac{80}{28} \approx 23$ N

Q4 A 800-kg car travels to the north initially and its velocity is shown in the following graph. Determine the magnitude and direction of the net force on the car in each of the intervals A, B, C and D.

A: $a = gradient = 1.0$ ms^{-2}, $F_{net} = 800 \times 1 = 800$ N north

B: constant velocity, $F_{net} = 0$

C: $a = gradient = \frac{-20}{35} = -0.5714$ ms^{-2}, $F_{net} = 800 \times (-0.5714) \approx -460$ N

i.e. 460 N south D: 460 N south

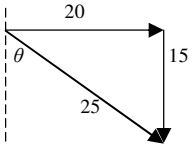
Q5 The velocity of a 800-kg car is 10 ms^{-1} north when a net force of 1000 N east acts on it. Determine the magnitude and direction of the car's acceleration.

$a = \frac{F_{net}}{m} = \frac{1000}{800} = 1.25$ ms^{-2} east

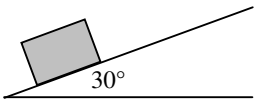
Q6 The velocity of a 800-kg car changes from 15 ms^{-1} north to 20 ms^{-1} east in 10 s. Determine the magnitude and direction of the average net force on the car.

$a_{av} = \frac{\Delta v}{\Delta t} = \frac{25}{10} = 2.5$ ms^{-2}, $\theta = \tan^{-1}\left(\frac{20}{15}\right) \approx 53°$

$F_{net,av} = ma_{av} = 800 \times 2.5 = 2000$ N, S53°E



Q7 A 5-kg box slides up a frictionless plane inclined at 30° to the horizontal. It has an initial speed of 5 ms^{-1}. How long will it take to return to its original position?



Uphill motion: $F_{net} = -mg\sin\theta = -5 \times 9.8 \times \sin 30° = -5 \times 4.9$, $a = -4.9$,

$t = \frac{v-u}{a} = \frac{-5}{-4.9} \approx 1.02$ s. If there is no friction, it will take the same time to return to its original position. .: Total ≈ 2.04 s

Q8 A 5-kg box slides up a plane inclined at 30° to the horizontal. The coefficient of friction between the box and the plane is $0.1\sqrt{3}$. The box has an initial speed of 5 ms^{-1}. How long will it take to return to its original position?

Uphill motion: $F_{friction} = \mu N = 0.1\sqrt{3} \times 5 \times 9.8\cos 30° = 4.9 \times 1.5$

$F_{net} = -mg\sin\theta - F_{friction} = -5 \times 9.8 \times \sin 30° - 4.9 \times 1.5 = -4.9 \times 6.5$,

$a = \frac{F_{net}}{m} - 6.37$, $t = \frac{v-u}{a} = \frac{-5}{-6.37} \approx 0.785$ s, $v^2 = u^2 + 2as$, $s \approx 1.962$ m

Downhill motion: $F_{net} = mg\sin\theta - F_{friction} = 5 \times 4.9 - 4.9 \times 1.5 = 4.9 \times 3.5$,

$a = 3.43$, $s = ut + \frac{1}{2}at^2$, $t \approx 1.0675$ s. Total ≈ 1.85 s

Q9 A 75-kg parcel is tied to a 10-m bungee cord which is fastened to a bridge. The cord has a force constant of 147 Nm^{-1}. The parcel falls a vertical distance of 26 m to a stop when it is dropped from the bridge. Determine the magnitude and direction of the acceleration of the parcel at the following distances below the bridge. (i) 5 m (ii) 10 m (iii) 12 m (iv) 15 m (v) 26 m. Ignore air resistance.

(i) 9.8 ms^{-2} downward

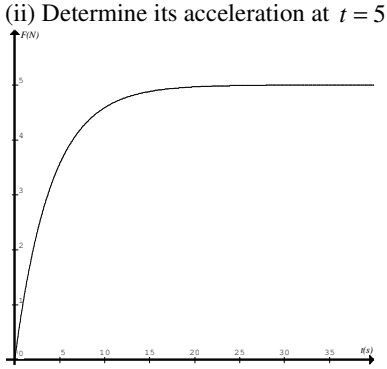
(ii) 9.8 ms^{-2} downward

(iii) The cord is extended by 2m, $a = \frac{F_{net}}{m} = \frac{75 \times 9.8 - 147 \times 2}{75} = 5.88$ ms^{-2} downward

(iv) $a = \frac{75 \times 9.8 - 147 \times 5}{75} = 0$

(v) $a = \frac{147 \times 16 - 75 \times 9.8}{75} = 21.56$ ms^{-2} upward

Q10 The graph shows the air resistance on an object as it falls vertically towards the ground. It reaches terminal velocity at some stage of the fall. (i) Determine the mass of the object. (ii) Determine its acceleration at $t = 5$.



(i) At terminal velocity, air resistance stays constant, weight force = air resiatance = 5 N (graph)

$\frac{weight}{g} = \frac{5}{9.8} \approx 0.5$ kg

(ii) At $t = 5$,

air resistance ≈ 3.8 N

$a = \frac{F_{net}}{m}$

$\approx \frac{5 - 3.8}{0.5} = 2.4$ ms^{-2}