PHYSICS 534

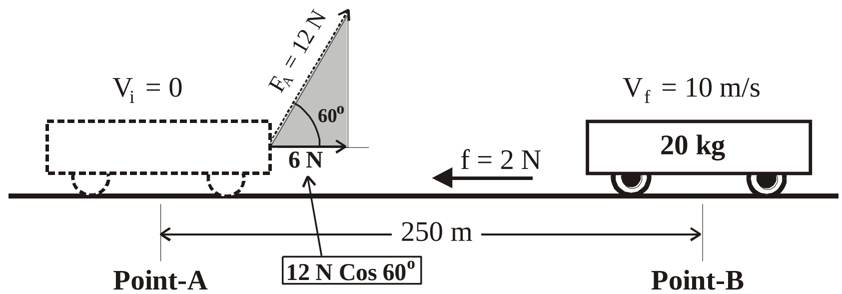
ANSWERS

EXERCISE-38 Kinetic Energy Part-3 /3

Paul Dirac received the the Nobel prize in physics in 1933 for his work in atomic theory.

DIRAC

1. A force of 12 N, acting 60° from the horizontal, is applied to a 20 kg cart, initially at rest, resulting in a final velocity of 10 m/s. If the force of friction is 2 N, answer the following questions concerning the cart in going from Point-A to Point-B (a distance of 250 m).



a) Was the cart at rest? (while going from A to B)	**No**
b) What was the applied force?	**12 N 60° N of E**
c) What was the horizontal component of the applied force (F_H)?	**6 N Right**
d) What was the frictional force?	**2 N Left**
e) What was the resultant force? (Use $F_R = F_H - f$)	**4 N Right**
f) What was the acceleration?	**0.2 m/s²**
g) What was the initial E_K of the cart? (Use $E_K = ½mv^2$)	**0**
h) What was the final E_K of the cart? (Use $E_K = ½mv^2$)	**1000 J**
i) How much work was done on the cart? (ΔE_K)	**1000 J**

j) What becomes of the work done ***on the cart***?

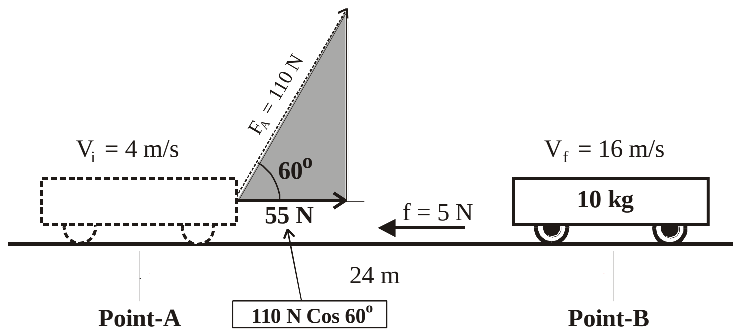
To accelerate the cart (increase its velocity).

k) How much work was done to overcome friction? (Use W = f s)	**500 J**
l) What was the total work done? (Use $W = F_H s$)	**1500 J**

m) Fill in the amounts of work done:

① To accelerate the cart	**1000 J**
② To raise the cart	**0**
③ To overcome friction	**500 J**
④ Total work done	**1500 J**

2. A force of 110 N, acting 60° from the horizontal, is applied to a 10 kg cart whose initial velocity is 4 m/s. The final velocity is 16 m/s. If the frictional force of 5 N, answer the following questions concerning the cart in going from Point-A to Point-B (a distance of 24 m).



a) Was the cart at rest? (while going from A to B) **No**

b) What was the applied force? **110 N 60° N of E**

c) What was the horizontal component of the applied force (F_H)? **55 N Right**

d) What was the frictional force? **5 N Left**

e) What was the resultant force? (Use $F_R = F_H - f$) **50 N Right**

f) What was the acceleration? **5 m/s²**

g) What was the initial E_K of the cart? (Use $E_K = ½mv^2$) **80 J**

h) What was the final E_K of the cart? (Use $E_K = ½mv^2$) **1280 J**

i) How much work was done on the cart? (ΔE_K) **1200 J**

j) How much work was done to overcome friction? (Use W = f s) **120 J**

k) What was the total work done? (Use $W = F_H s$) **1320 J**

l) Fill in the amounts of work done:

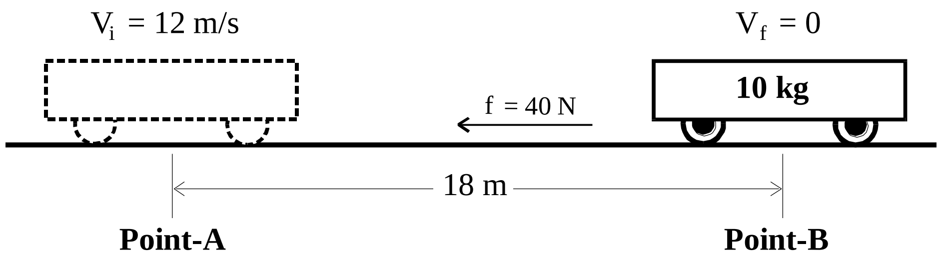
① To accelerate the cart **1200 J**

② To raise the cart **0**

③ To overcome friction **120 J**

④ Total work done **1320 J**

3. A 10 kg cart is traveling at 12 m/s towards the right. If a frictional force of 40 N stops the cart in a distance of 18 m, answer the following questions concerning the cart in going from Point-A to Point-B.



a) Was the cart at rest? (while going from A to B) **No**

b) What was the frictional force? **40 N Left**

c) What was the resultant force? **40 N Left**

d) What was the acceleration? **- 4 m/s²**

e) What was the initial E_K of the cart? (Use $E_K = ½mv^2$) **720 J**

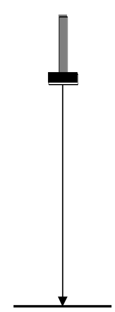
f) What was the final E_K of the cart? (Use $E_K = ½mv^2$) **0**

g) How much energy did the cart lose? (ΔE_K) **720 J**

h) Where did the energy lost by the cart go?

To overcome friction (lost as heat and sound)

4. A hammer falls from a scaffold and 1.5 s later strikes the ground with a kinetic energy of 157.5 J. What is the weight of the hammer? [14 N]



Find the velocity, then use the formula for E_K to find the mass.

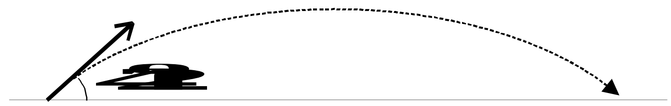
$$a = \frac{\Delta v}{t} = \frac{v_f - v_i}{t}$$

$$v_f = at + v_i = (10\ m/s^2)(1.5\ s) + 0 = 15\ m/s$$

$$\text{Since } E_K = \frac{mv^2}{2} \quad \text{Then } m = \frac{2E_K}{v^2} = \frac{2(157.5\ J)}{(15\ m/s)^2} = 1.4\ kg$$

$$\text{Thus, weight} = mg = (1.4\ kg)(10\ m/s^2) = 14\ N$$

5. A projectile, whose mass is 800 g, is shot into the air with a velocity of 25 m/s, 42^o N of E. Determine the kinetic energy of the projectile one second after it is fired. [157 J]



Find the vertical and horizontal components of the initial velocity.

$V_V = (25\ m/s)(\text{Sin } 42^o) = 16.7\ m/s$

$V_H = (25\ m/s)(\text{Cos } 42^o) = 18.6\ m/s$

One second later, the vertical and horizontal components of the velocity are:

$V_V = 16.7\ m/s - 10\ m/s = 6.7\ m/s$ and $V_H = 18.6\ m/s$

Thus, the speed of the projectile (one second later) is:

$v = \sqrt{(6.7\ m/s)^2 + (18.6\ m/s)^2} = 19.8\ m/s$

We can now calculate the kinetic energy of the projectile

$$E_K = \frac{m v^2}{2} = \frac{(0.8\ kg)(19.8\ m/s)^2}{2} = 156.8\ J = 157\ J$$

6. Starting from rest, a car reaches a velocity of 60 m/s in a distance of 120 m. Assuming the system is frictionless and knowing that the motor of the car produces a force of 3 x 10^4 N, calculate the mass of the car. [2 x 10^3 kg]

Note that the work done to overcome friction equals the kinetic energy of the car. Thus, we first find the work done to overcome friction and then use the E_K formula to find the mass of the car.

$W = f\,s = (3 \times 10^4\ N)(120\ m) = 3.6 \times 10^6\ J$

Since $E_K = \frac{m v^2}{2}$ then $m = \frac{2 E_K}{v^2} = \frac{2(3.6 \times 10^6\ J)}{(60\ m/s)^2} = 2000\ kg$

7. The mass of an electron is 1.67 x 10^{-27} kg. What work must be done on the electron in order to give it a speed of 2.5 x 10^7 m/s? [5.2 x 10^{-13} J]

$$E_K = \frac{m v^2}{2} = \frac{(1.67 \times 10^{27}\ kg)(2.5 \times 10^7\ m/s)^2}{2} = 5.2 \times 10^{-13}\ J$$

8. A bullet of mass 2 g, traveling at 500 m/s, is fired at a piece of wood. The bullet emerges from the wood with a speed of 100 m/s. If the retarding force of friction was 4800 N, calculate the thickness of the piece of wood. [5 cm]

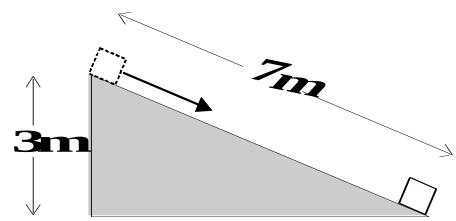
The work done in stopping the bullet is equal to the loss in E_K of the bullet.

$$\Delta E_K = E_{K\,final} - E_{K\,initial} = \frac{m v_f^2}{2} - \frac{m v_i^2}{2}$$

$$= \frac{(0.002\ kg)(100\ m/s)^2}{2} - \frac{(0.002\ kg)(500\ m/s)^2}{2} = -240\ J$$

Since $W = f\,s$ $\quad s = \frac{W}{f} = \frac{-240\ J}{-4800\ N} = 0.05\ m = 5\ cm$

9. An 8 kg block of wood slides from rest at the top of an inclined plane whose height is 3 m and length is 7 m (see diagram).



If the kinetic energy of the block at the bottom of the incline is 75.4 J, find the c

The angle of the incline is: $\sin^{-1} A = \frac{3}{7}$ $\quad A = 25.4^o$

The acceleration of the incline is: $a = g \sin A = (10\ m/s^2)(\sin 25.4^o) = 4.3\ m/s^2$

The final velocity of the block at the bottom of the incline is:

$v_f = \sqrt{2as} = \sqrt{2(4.3\ m/s^2)(7\ m)} = 7.8\ m/s$

Thus, without friction, the E_K of the block is: $E_K = \frac{mv^2}{2} = \frac{(8\ kg)(7.8\ m/s)^2}{2} = 243.4\ J$

Therefore, the energy lost due to friction is: $243.4\ J - 75.4\ J = 168\ J$

Since $W = f\,s$ $\quad f = \frac{W}{s} = \frac{-168\ J}{7\ m} = -24\ N$

Using the formula for frcition, we can calculate the coefficient of friction.

$f = kN$ $\quad k = \frac{f}{N} = \frac{24\ N}{(80\ N)(\cos 25.4^o)} = 0.33$

10. Two vehicles, X and Y, are traveling at the same speed. Vehicle-X has twice the kinetic energy of vehicle-Y. What is the value of the following ratio?

$$\frac{\text{Mass of vehicle-X}}{\text{Mass of vehicle-Y}}$$

$$\frac{2E_K = \frac{m_X v^2}{2}}{1E_K = \frac{m_Y v^2}{2}} \quad \text{or} \quad \frac{2}{1} = \frac{m_X}{m_Y} \quad \text{or} \quad \frac{m_X}{m_Y} = \frac{2}{1}$$

❖❖❖❖❖❖❖❖❖❖❖❖❖❖❖❖