Solution S10E 1 *Distribution of Points*

2. a) 7 points

The work required to compress the spring must be at least as great as the kinetic energy the spring imparts to the block, so

$W_{min} = \Delta K$ — 2 points

Since the block is released from rest, its kinetic energy increase is

$\Delta K = \frac{1}{2}mv^2 = \frac{1}{2}(3\text{ kg})(10\frac{\text{m}}{\text{s}})^2$ — 3 points

Therefore $W_{min} = 150$ joules — 2 points

b) 8 points

The linear momentum of the system, initially zero, is conserved, so that the momentum of each block has the same magnitude:

$|p_1| = |p_2|$ — 1 point

For each block, $p = mv$ — 1 point

Therefore $|m_1v_1| = |m_2v_2|$

and $|v_1| = \frac{m_2}{m_1}|v_2| = 3|v_2|$ — 1 point

Energy is conserved as the blocks separate. — 1 point

Therefore
$\frac{1}{2}m_1v_1^2 + \frac{1}{2}m_2v_2^2 = 150\text{ J}$ — 1 point

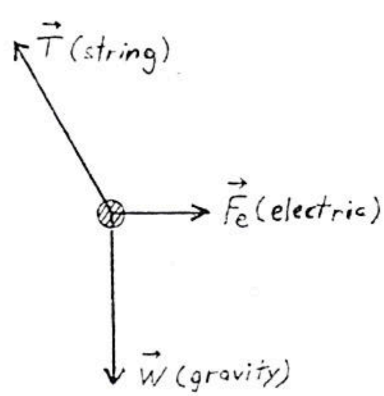
Eliminate v_1 by using preceding momentum conservation equation:
$\frac{1}{2}m_1(3v_2)^2 + \frac{1}{2}m_2v_2^2 = 150\text{ J}$ — 1 point

Substituting $m_1 = 1$ kg, $m_2 = 3$ kg gives
$12\,v_2^2 = 300$ — 1 point

so $v_2 = \sqrt{25} = 5$ m/s and $v_1 = 3\cdot5 = 15$ m/s — 1 point

Total 15 points

3. a) 4 points



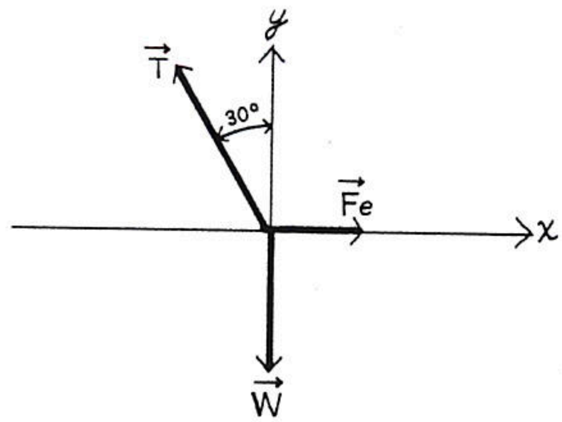
1 point for each force, with correct direction and an adequate label. — 3 points

If lengths of vectors correctly represent relative magnitudes of forces. — 1 point

SIDE 1

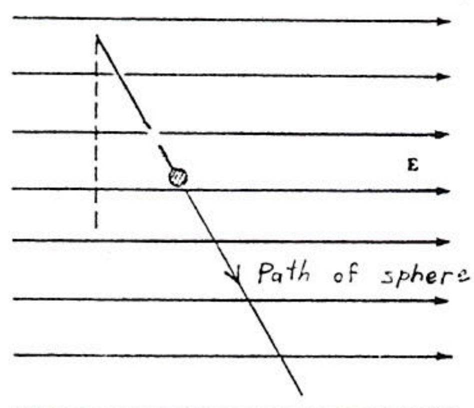
Solution | *Distribution of Points*

b) 7 points



Solution	Distribution of Points
Vector sum of forces is zero: $\vec{T} + \vec{F_e} + \vec{W} = 0$	1 point
Considering y-components, $T \cos 30° = W = mg$, so	1 point
$T = \dfrac{5 \times 10^{-3} \cdot 10}{\frac{\sqrt{3}}{2}} = .058\ \text{N}$	1 point
Considering x-components, $F_e = T \sin 30°$ (or $mg \tan 30°$)	1 point
Field and force are related by $E = F_e/Q$, so	1 point
$E = \dfrac{mg \tan 30°}{Q} = \dfrac{5 \times 10^{-2} \cdot (\sqrt{3}/3)}{5 \times 10^{-6}} = 5.8 \times 10^{3}\ \text{N/C}$	2 points

c) 4 points



Solution	Distribution of Points
After the string is cut, the only forces are gravity, which acts down, and the electrical force, which acts to the right.	1 point
The resultant of these two forces causes a constant acceleration from rest along the line of the string.	1 point
The path is therefore down and to the right,	1 point
a straight line along the direction of the string as shown above.	1 point
Total	15 points

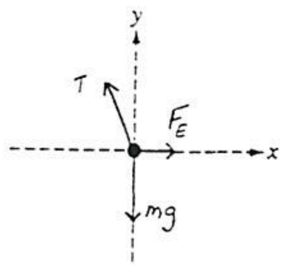
S10Q2

1998 Physics B Solutions

Distribution of points

Question 2 (15 points)

(a) 3 points



One point for each correctly drawn and labeled force — 3 points

One point was deducted (up to a maximum of three points) for each extra force, for any missing arrowheads, and for any missing labels

(b) 3 points

For using the correct expression for the magnitude of the electric field (as indicated by either of the following two equations) — 1 point

$$E = \frac{F}{q}$$

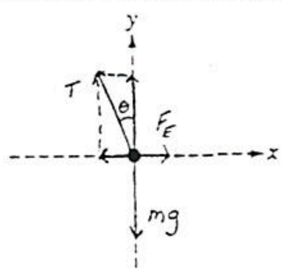
$$E = \frac{0.032\ \text{N}}{80.0 \times 10^{-6}\ \text{C}}$$

For the correct magnitude of the field — 1 point
$E = 400$ N/C

For indicating the correct direction for the field (e.g. $-x$, or to the left) — 1 point

(c) 4 points

For some indication of resolving the tension into x and y components — 1 point



For the correct force equations using these components — 1 point
$T \sin\theta = F_E$
$T \cos\theta = mg$

1998 Physics B Solutions

Distribution of points

Question 2 (continued)

(c) (continued)

Dividing these equations

$$\tan\theta = \frac{F_E}{mg}$$

For determining the value of the angle θ — 1 point

$$\tan\theta = \frac{(0.032\ \text{N})}{(9.8\ \text{m/s}^2)(0.01\ \text{kg})}$$

$\theta \approx 18°$

Using trigonometry to find the perpendicular distance x from the wall

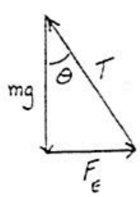
$$\sin\theta = \frac{x}{0.30\ \text{m}}$$

For the correct value for x — 1 point

$x = 0.09$ m

(Alternate solution I) — *(Alternate points)*

For some indication that the three forces are in equilibrium, e.g. drawing the triangle representing the vector addition — *1 point*



For using trigonometry to find the angle θ — *1 point*

$$\tan\theta = \frac{F_E}{mg}$$

For determining the value of the angle θ — *1 point*

$$\tan\theta = \frac{(0.032\ \text{N})}{(9.8\ \text{m/s}^2)(0.01\ \text{kg})}$$

$\theta \approx 18°$

Si0i 2

Distribution of points

Question 2 (continued)

(c) (continued)

Using trigonometry to find the perpendicular distance x from the wall

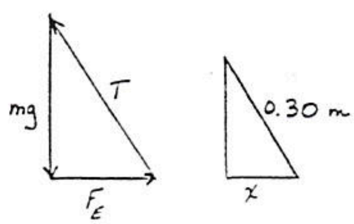
$$\sin\theta = \frac{x}{0.30\text{ m}}$$

For the correct value for x — *1 point*

$x = 0.09$ m

(Alternate solution II) — *(Alternate points)*

For indicating both triangles to be used in the method of similar triangles — *2 points*



Calculating the length of the hypotenuse (the tension) in the force triangle

$$T = \sqrt{(0.098\text{ N})^2 + (0.032\text{ N})^2} = 0.103\text{ N}$$

For correctly setting up the proportionality between the sides of the triangles — *1 point*

$$\frac{x}{0.30\text{m}} = \frac{0.032\text{ N}}{0.103\text{ N}}$$

For the correct answer — *1 point*

$x = 0.09$ m

SIDE 2

Question 2 (continued)

Distribution of points

(d)

i. 4 points

For using Newton's law to calculate the acceleration due to the electric force — 1 point

$a = \frac{F}{m} = \frac{0.032\text{N}}{0.01\,\text{kg}} = 3.2\ \text{m/s}^2$

For vector addition of the two accelerations — 1 point

$a^2 = (3.2\ \text{m/s}^2)^2 + (9.8\ \text{m/s}^2)^2$

For the correct magnitude of the resultant acceleration — 1 point

$a = 10.3\ \text{m/s}^2$

Using trigonometry to calculate the angle θ

$\tan\theta = \frac{(9.8\ \text{m/s}^2)}{(3.2\ \text{m/s}^2)}$

(One could also realize that the acceleration must be opposite the tension, whose angle may have been determined in part (c))

For the correct value of θ — 1 point

$\theta = 72°$ below the x-axis or 18° to the right of the y-axis

ii. 1 point

For correctly indicating that the ball moves in a straight line, down and to the right (via words or a figure), or indicating that the ball has a horizontal acceleration and a vertical acceleration due to gravity — 1 point