## Solutions

Marking: **M1** a correct method, **A1** the correct answer, **B1** an independent mark.

Each answer shows the steps, then the **result**.

**2.1**

HTTP application; TCP transport

IP network; Ethernet link

**2.2**

100/158

$\approx$ **63**%

**2.3**

$8 \times 10^6$ bits

$8 \times 10^6 / 10^7$

= **0.8 s**

**2.4**

$10^9 \times 0.1 = 10^8$ bits

= **12.5 MB**

the sender must have 12.5 MB unacknowledged to keep the link full

**3.1**

(a) $6 \times 10^6 / 2 \times 10^8$ = **30 ms**

(b) $8 \times 10^7$ bits; $\div 10^8$ = **0.8 s**

(c) 60 ms set-up +0.8 s +30 ms $\approx$ **0.89 s**

(d) propagation: sending 8000 bits takes 80 µs, against 30 ms of travel

**3.2**

(a) a layer can change without changing the others, e.g. Wi-Fi in place of Ethernet with the same TCP; each layer is simpler to design and test

(b) every header adds overhead; work can be repeated in several layers, such as error checks

(c) put functions such as reliability in the end hosts, and keep the network core simple

**3.3**

(a) one way: 72 000 km/3 $\times 10^8 \approx 0.24$ s; RTT $\approx$ **0.48 s**

(b) 65 536 $\times$ 8/0.48 $\approx$ **1.1 Mbit/s**, whatever the link speed

(c) $50 \times 10^6 \times 0.48 = 2.4 \times 10^7$ bits = **3 MB**



(d) low orbit: its RTT is about $4 \times 550$ km/$3 \times 10^8 \approx 7$ ms, so live talk has no half-second lag, and normal TCP windows fill the link



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